# Capabilities of Data Integration and Prediction

## -Some implications to the AWCI Next Stage-

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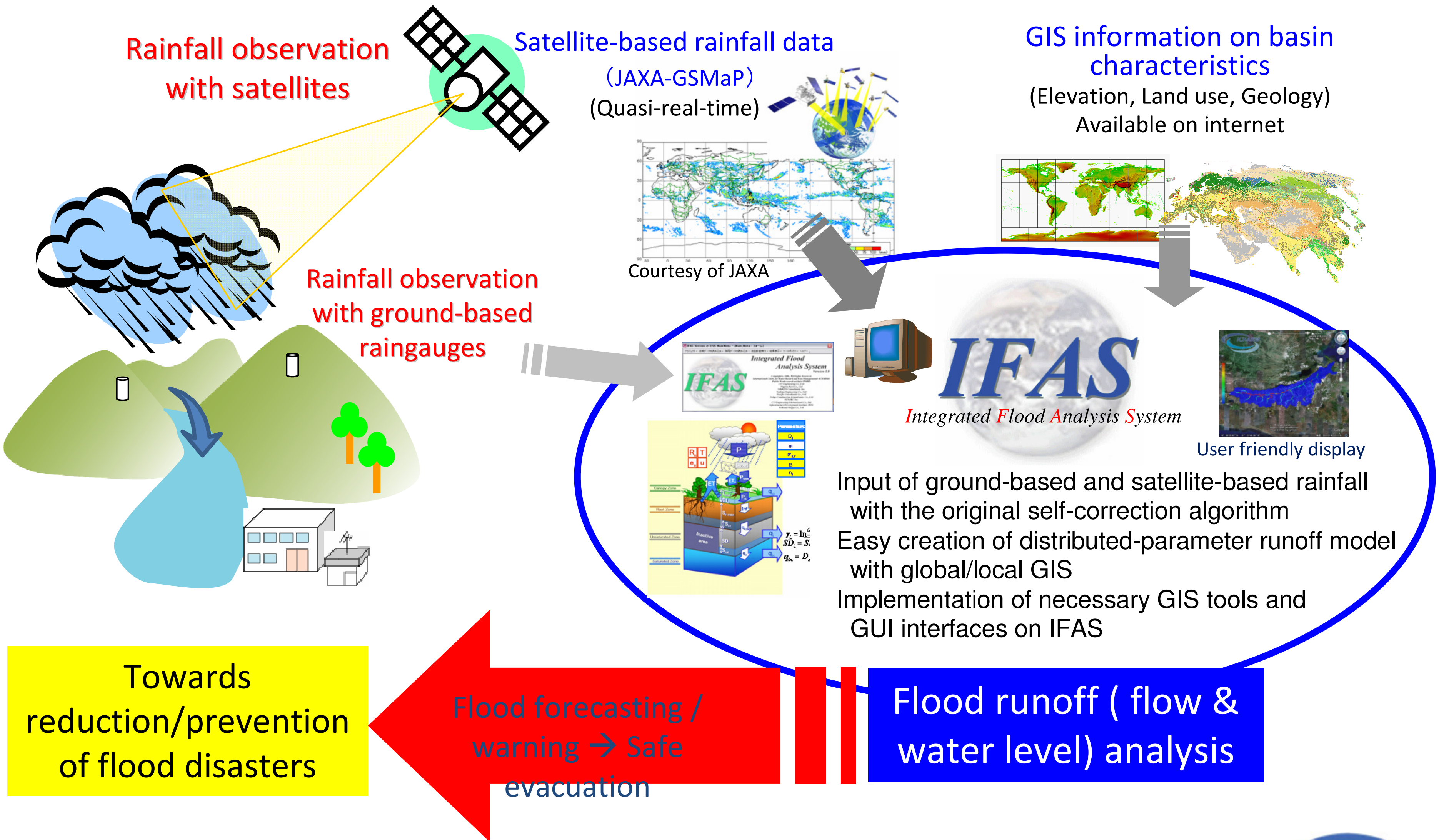
IFAS

IFNet
International Flood Network

ICHARM

# Integrated Flood Analysis System (IFAS)

## Flood runoff analysis system with satellite-based rainfall & global GIS information

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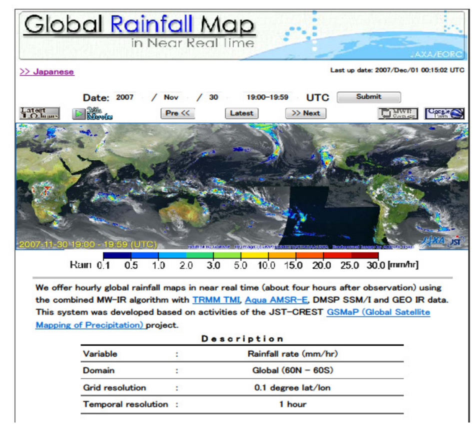
# Satellite-based rainfall data

- There is no necessity for installation and maintenance of a rain gauge or transmission equipment .
  - Ground-based rainfall data are indispensable to get highly-accurate flood runoff analysis and forecast.
- Almost the worldwide coverage and a consistent accuracy are obtained.
- Resolution (time and space) and observation accuracy are low compared with properly-distributed ground-based rainfall data.

| Product name | 3B42RT | CMORPH | **GSMaP_NRT** |
| --- | --- | --- | --- |
| Developer and provider | NASA/GSFC | NOAA/CPC | JAXA/EORC |
| Coverage | N60° - S60° | | |
| Resolution | 0.25° | 0.25° | **0.1°** |
| Resolution time | 3 hours | 3 hours | **1 hour** |
| Time lag | 10 hours | 15 hours | **4 hours** |
| Coordinate system | WGS | | |
| Historical data | Dec 1997- | Dec 2002- | Dec. 2007～ |
| Sensors | TRMM/TMI<br>Aqua/AMSR-E<br>AMSU-B<br>DMSP/SSM/I<br>IR | Aqua/AMSR-E<br>AMSU-B<br>DMSP/SSM/I<br>TRMM/TMI<br>IR | TRMM/TMI<br>Aqua/AMSR-E<br>ADEOS-Ⅱ/<br>AMSR<br>SSM/I<br>IR<br>AMSU-B |




**GSMaP_nRT**

http://sharaku.eorc.jaxa.jp/GSMaP/index.htm

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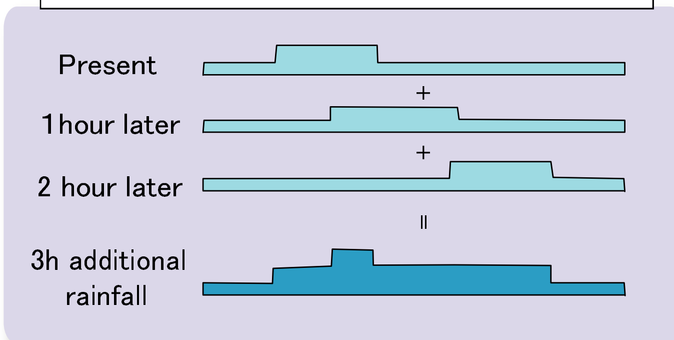
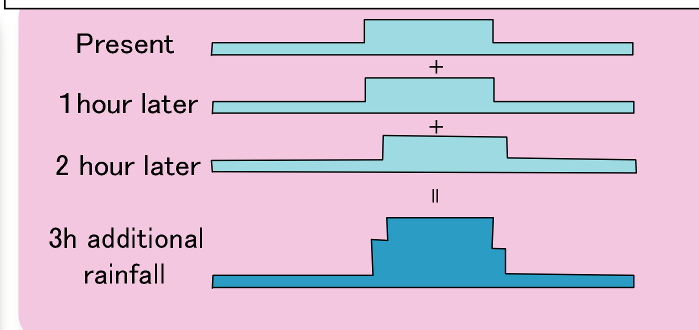
# Algorithm for self-correction of satellite-based rainfall data without any ground-based rainfall data

**Moving fast → Underestimation**

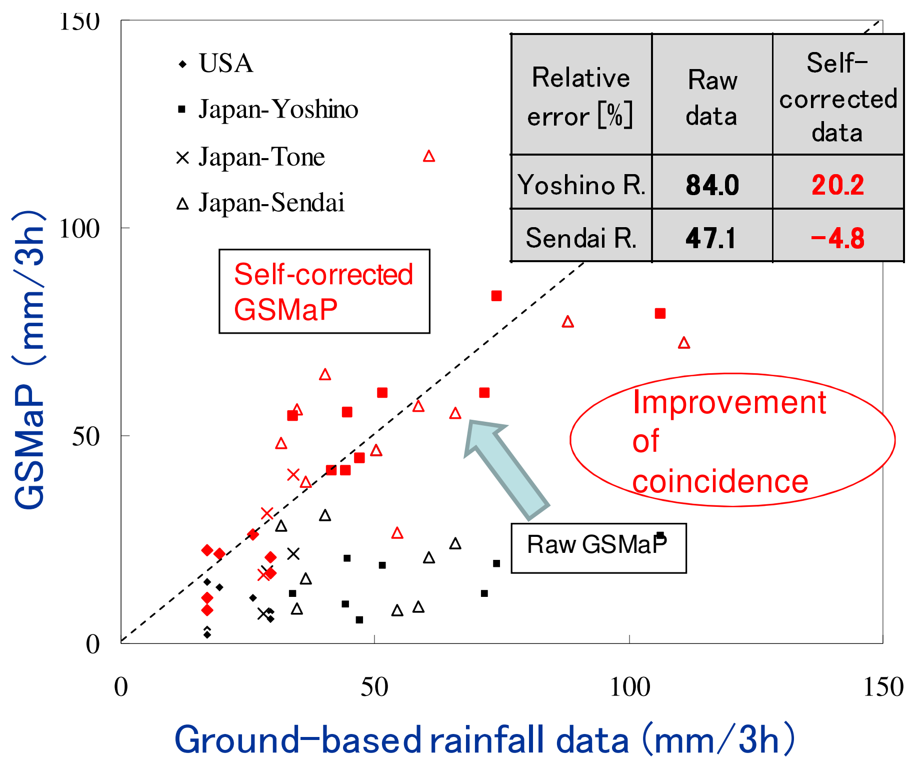



**Small spatial variance of cumulative rainfall on a certain scale**

**Moving slowly → Better coincidence**

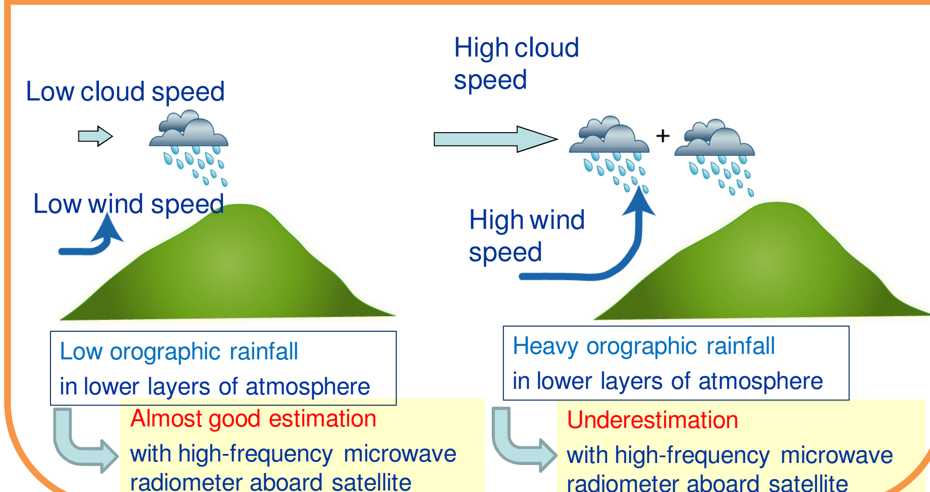



**Large spatial variance of cumulative rainfall on a certain scale**




| Relative error [%] | Raw data | Self-corrected data |
|---|---|---|
| Yoshino R. | **84.0** | **20.2** |
| Sendai R. | **47.1** | **-4.8** |

## A hypothesis on the reason why this self-correction is empirically effective.



# Main features of IFAS:

**Not only ground-based but also satellite-based rainfall data area applicable**

**Distributed-parameter flood runoff model creation using global GIS data**

**With limited historical / real-time hydrological databases in poorly-gauged rivers**

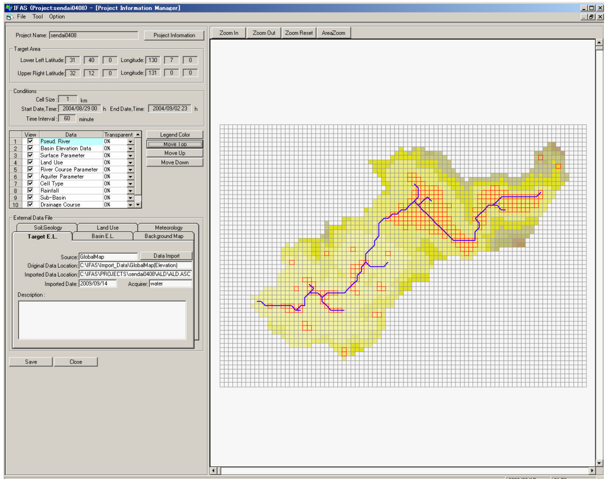
**All-in-one package for GIS data analyses**

**Free download for the executable program from ICHARM-IFAS website**
http://www.icharm.pwri.go.jp/index.html

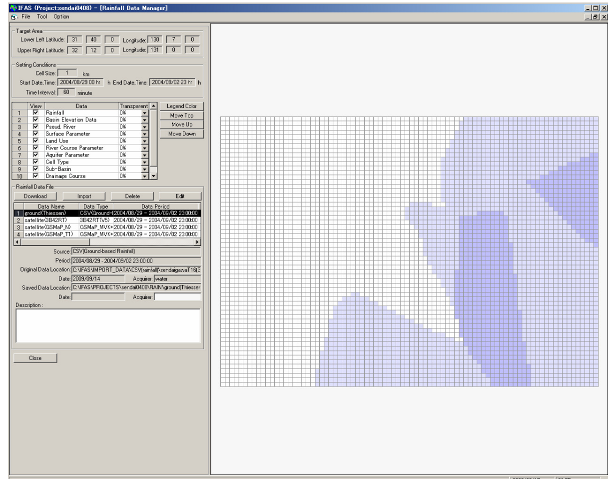
Prompt and efficient implementation of flood analysis and forecasting system even in poorly-gauged rivers
and
step-by-step improvement of accuracy
with the enhancement of in-situ hydrological observational network

# Interface display

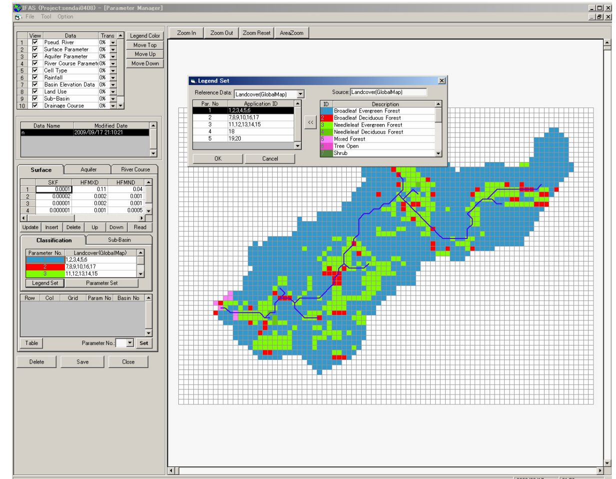
Main display



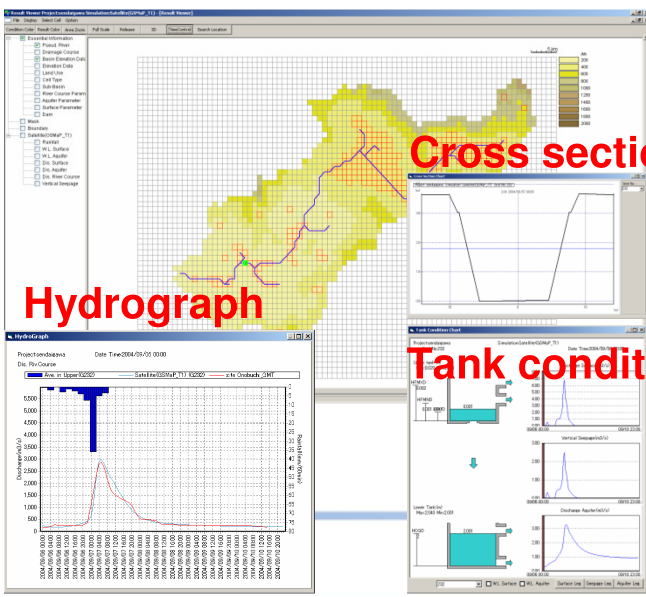
Edit display of rainfall data



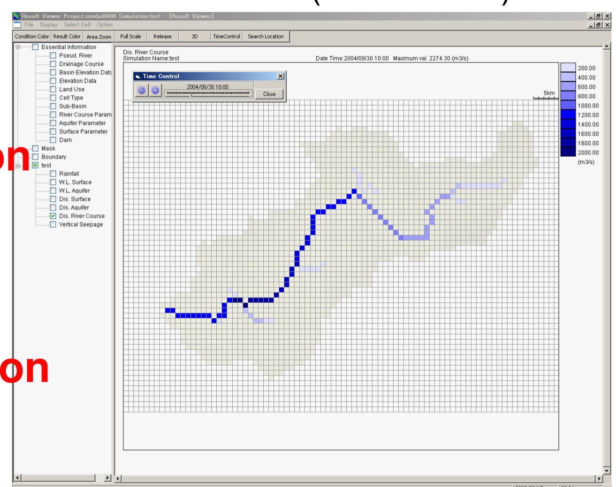
Setting display of parameter



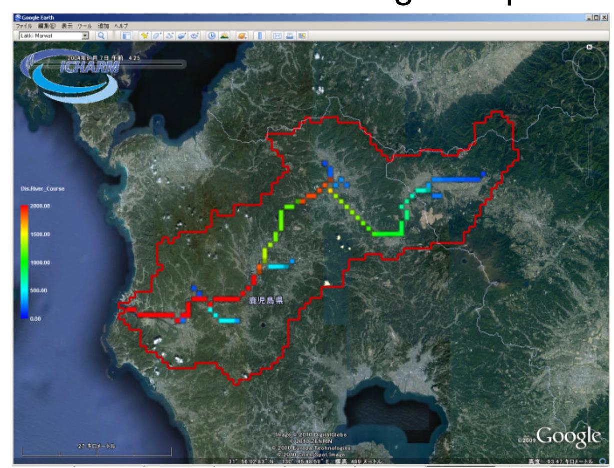
Calculation result




Calculation (Plane view)

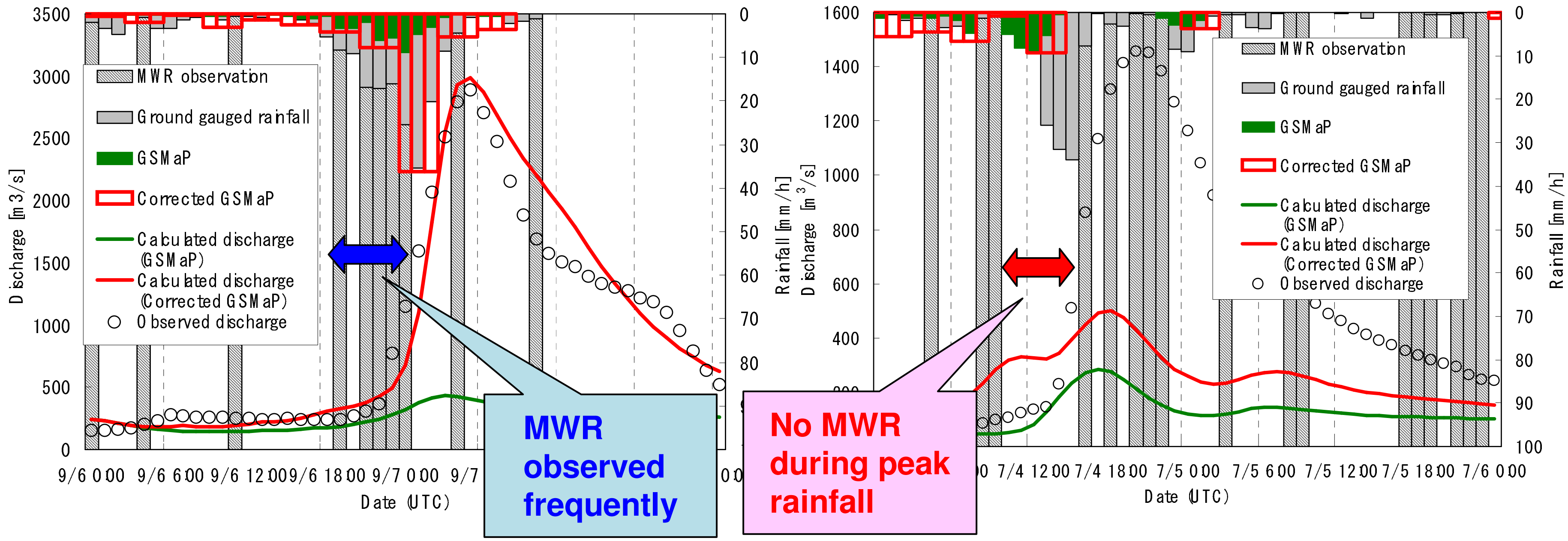


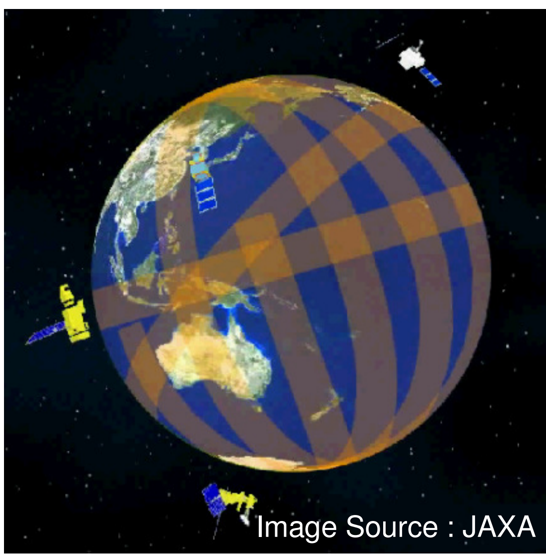
Plane view on Google Map



# Difference of frequency of Microwave (MWR) observation

**successful** case : Sendai river　　　　**unsuccessful** case : Kikuchi river




## Accuracy of rainfall distribution depends on the frequency of MWR observations

**(& accuracy of IR-based motion vectors)**

Ozawa et al (2010)

← Image of microwave observation

- MWR obs. is once a few hours on average, but not always guaranteed.
- During no MWR period, rainfall field is transferred by IR-based motion vector.

# Global Precipitation Measurement (GPM)

Current Observation System:
TRMM and other orbital Satellites, and 5 Geostationary Satellites

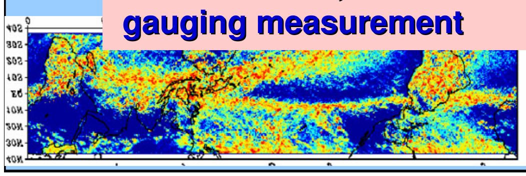
## Core Satellite

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**

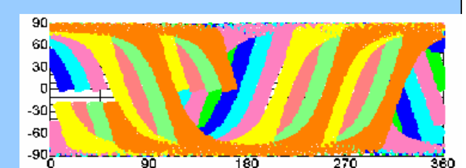


## 8 Constellation Satellites

Satellites with Micro-wave Radiometers

✧More frequent Observation

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

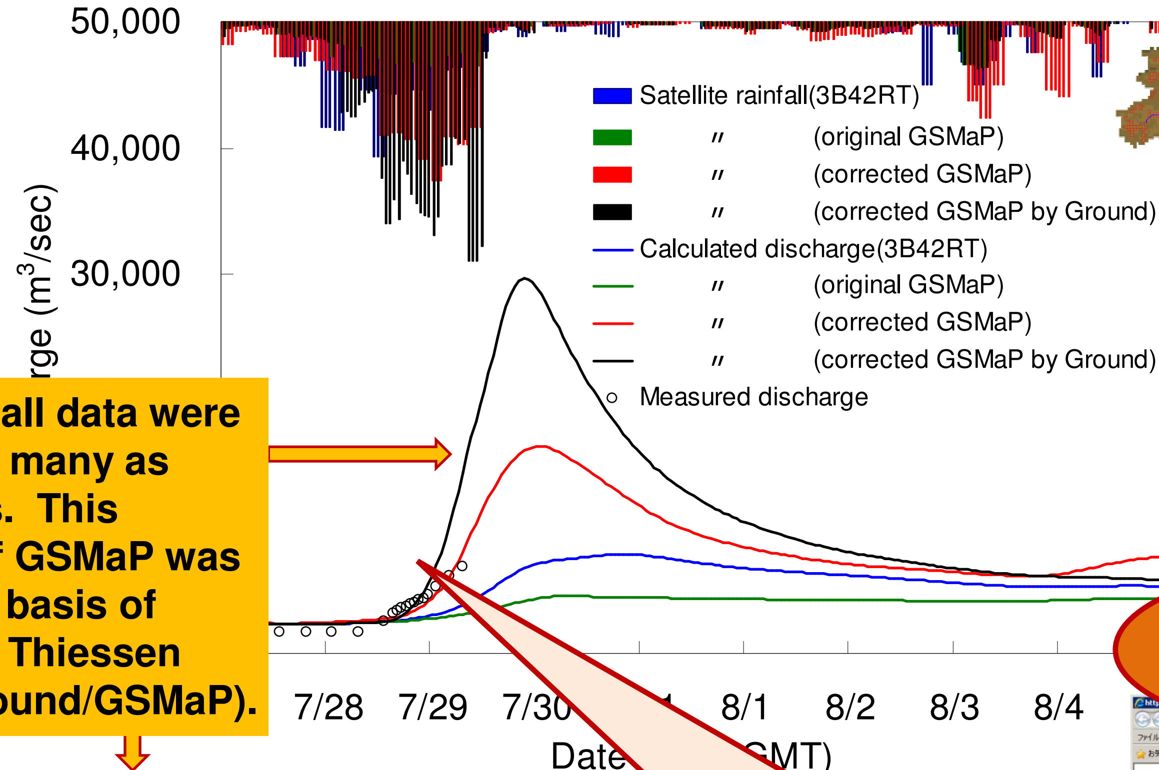


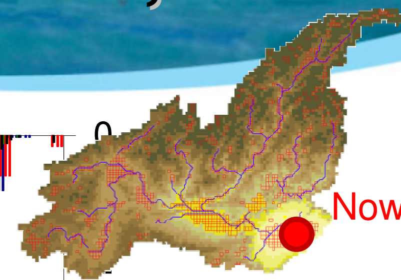

–Earth heating Phenomena
–Study of Climate Change
–Improvement of forecasting system

**Global Observation every 3 hours**

- IWRM
- Flood Forecasting
- Forecasting of crop productivity

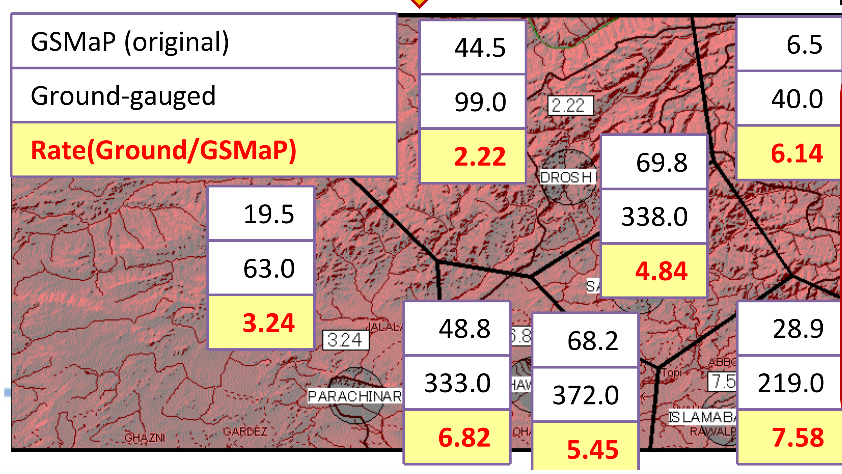
# IFAS-based runoff analysis: Kabul River, Pakistan



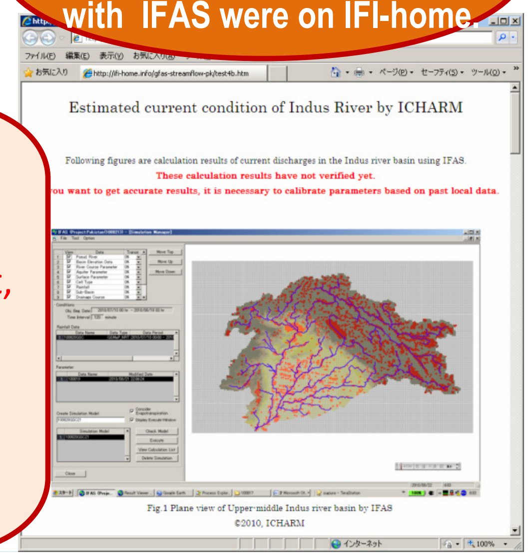

Calculated by
Default parameter

**Ground rainfall data were 2~7 times as many as GSMaP ones. This correction of GSMaP was made on the basis of each ratio of Thiessen polygon (Ground/GSMaP).**



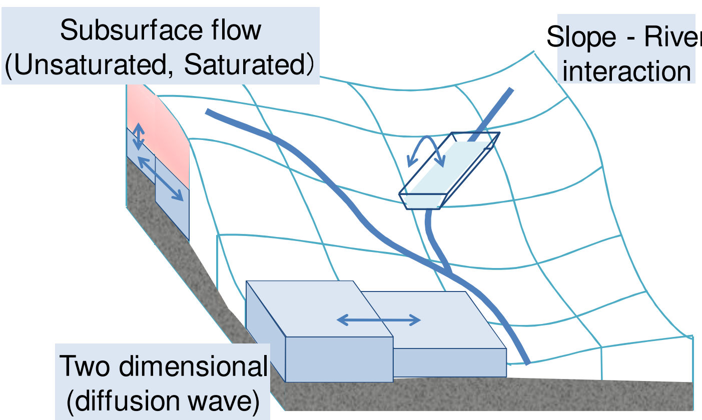

Alghouth the runoff simulation with ICHARM's self-correction algorithm without any ground-based rainfall data seemed best, this does not necessarily mean the truth. In any case, this shows the high potential of satellite-based runoff simulation.

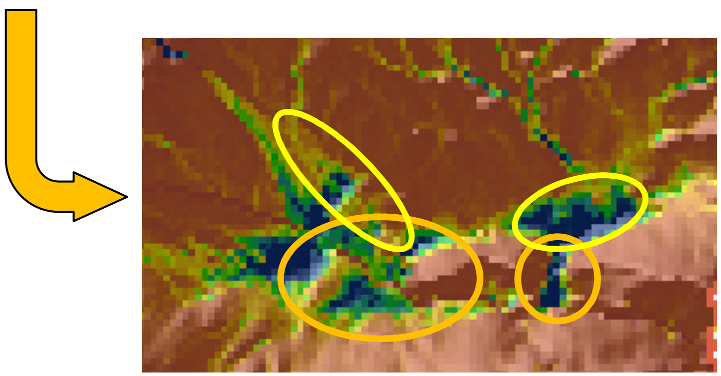
**Estimated hydrographs in upper & middle Indus river with IFAS were on IFI-home**



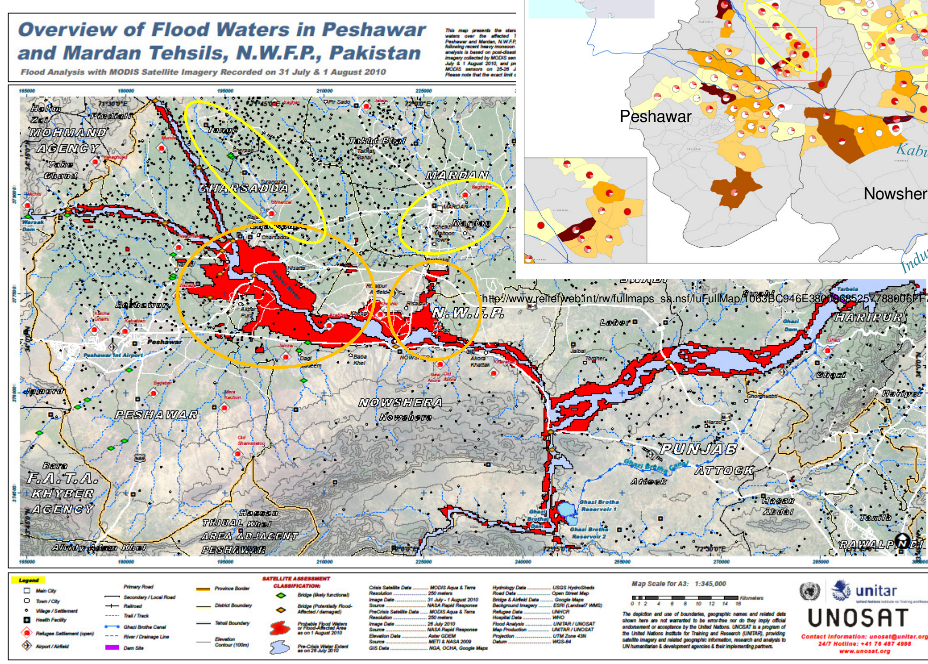
# Comparison between satellite-based inundation extent and inundation simulations with another ICHARM's Rainfall-Runoff-Inundation (RRI) Model for Pakistan flood, August 2010

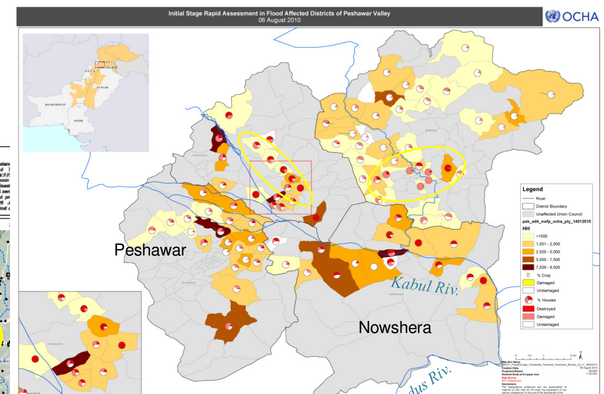
Runoff-inundation simulation can **interpolate <u>missing</u> satellite-based information** on flood inundation area caused by flash flood.



Sayama et al. (2011)




http://www.reliefweb.int/rw/fullmaps_sa.nsf/luFullMap/1063BC946E38008685257788006FF75B/$File/map.pdf?OpenElement

# IFAS-based flood management in ADB TA-7276-REG

- Implementing Early Warning system based on IFAS to Bengawan Solo river basin, Indonesia

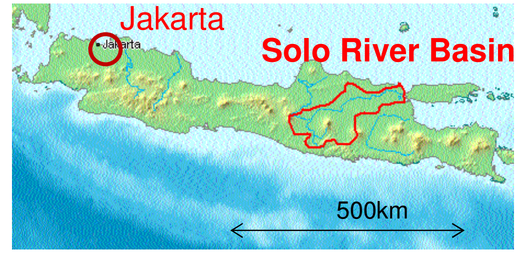
  * Implementing Early Warning system

  * Capacity Development

- Community Based Disaster Risk Management project in Pacal river basin

  * Creating Flood Hazard Map

  * Evacuation drill with alert by rainfall information and IFAS simulation




Flood in Dec.2007

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# Application to community-Based Disaster Risk Management along the Pacal River, a tributary to the Solo River, Indonesia

Preparation: Creating Flood Hazard Map and sharing role and responsibility in case of emergency

↓

Flood forecasting and warning : <u>Alert is disseminated from river management authorities through SMS based on with IFAS simulation or rainfall monitoring</u>

↓

Decision making: Community leader receives alert message and decides to evacuate

↓

Order/Advice: Evacuate Order/Advice for the community people is announced by the Community leader

↓

**Evacuation of people in flooding risk area**

Flood Hazard map


Advice to evacuate


Evacuation drill

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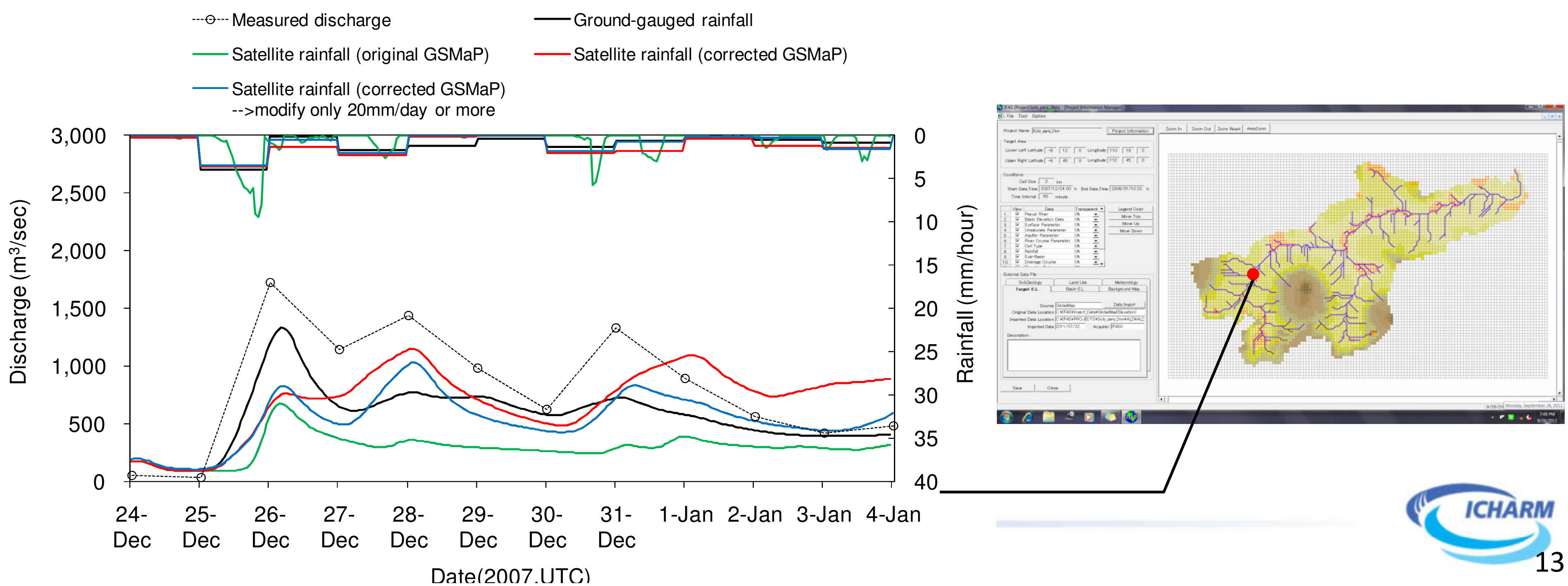
# IFAS installation to Bengawan Solo rive

- Neither raw satellite-based rainfall data (GSMaP / 3B42RT) and ICHARM's standard self-corrected GSMaP cannot reproduce the biggest flood event at the Solo River in December, 2007 very well.
- At the first phase, ground-based rainfall data will be input to IFAS. Due to the limited historical database for the verification, further validations will be conducted with future floods.
- ICHARM will make any correction method for satellite-based rainfall data with ground-based observation and/or numerical weather simulation.

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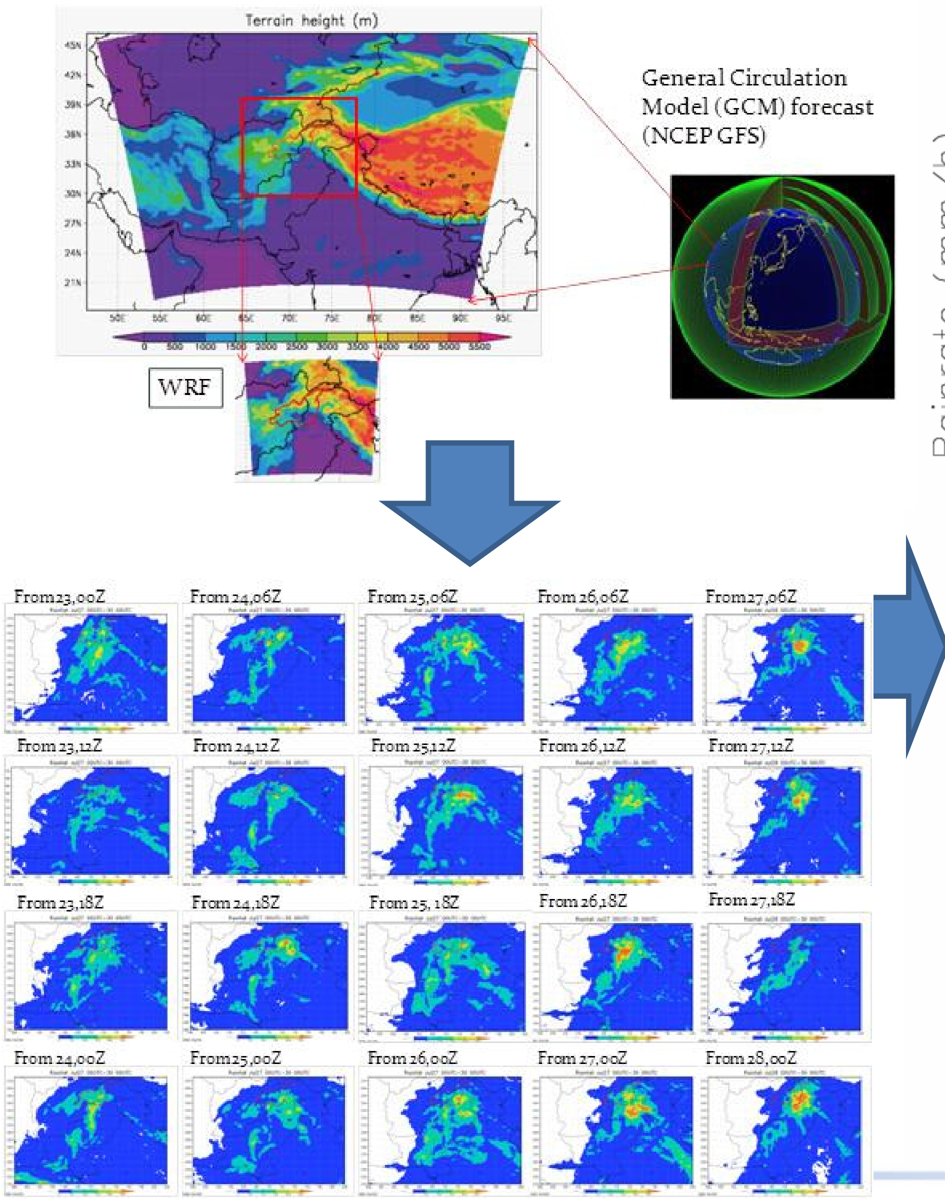
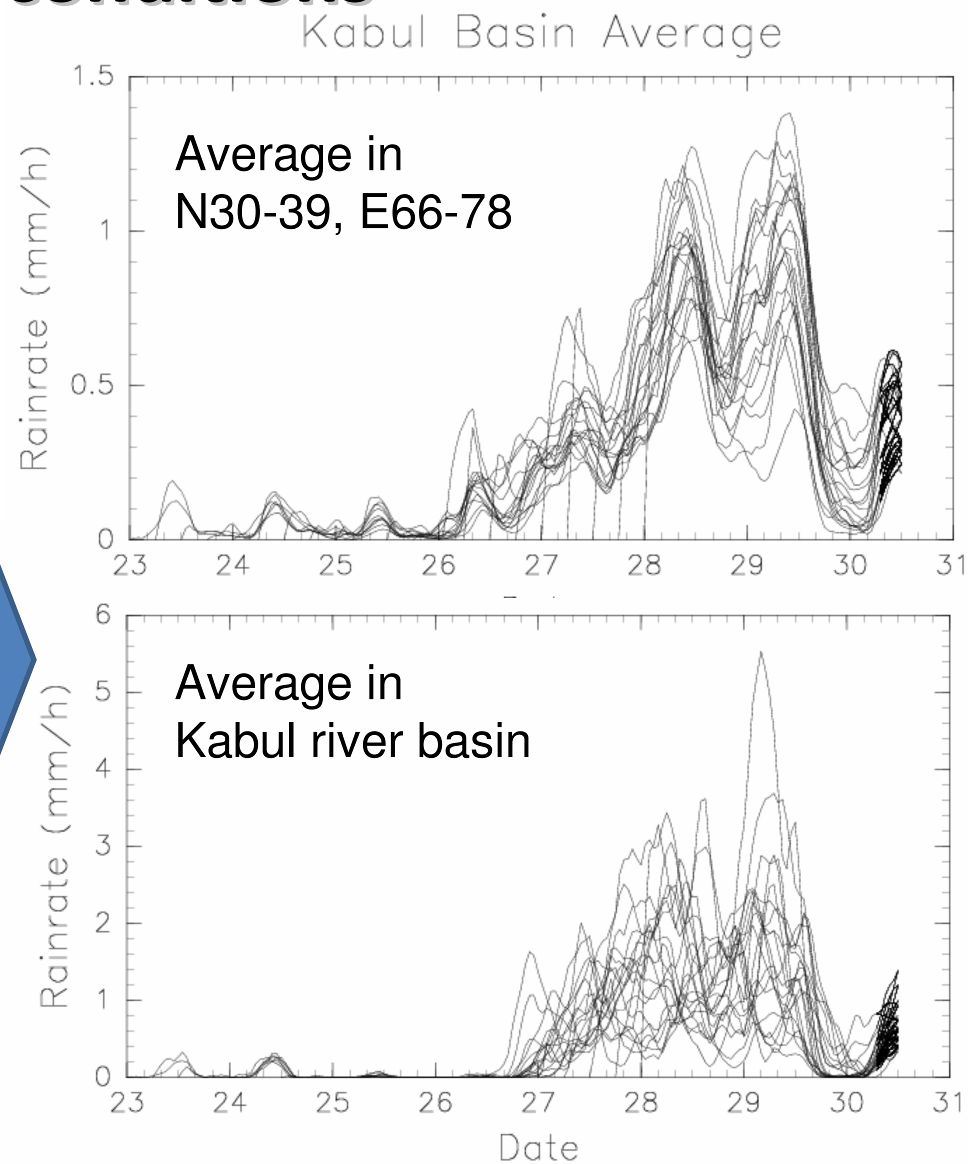
# Rainfall downscaling & forecasting with different initial conditions

Ushiyama et al. (2011)




Ensemble of rainfall forecast with WRF

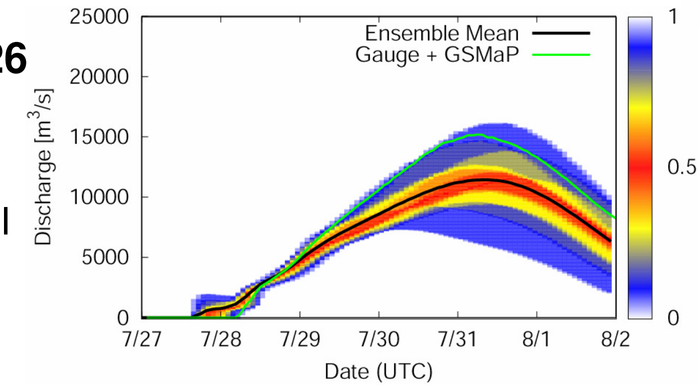
# Ensemble inundation forecast with RRI Model

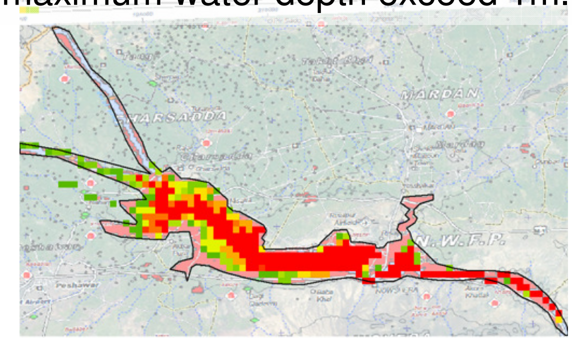
Hydrograph at Kabul
Frequency distribution by 13 members

Inundation probability
The ratio of members which maximum water depth exceed 1m.

**Forecast at July 26**
**(23 00Z -26 00Z)**

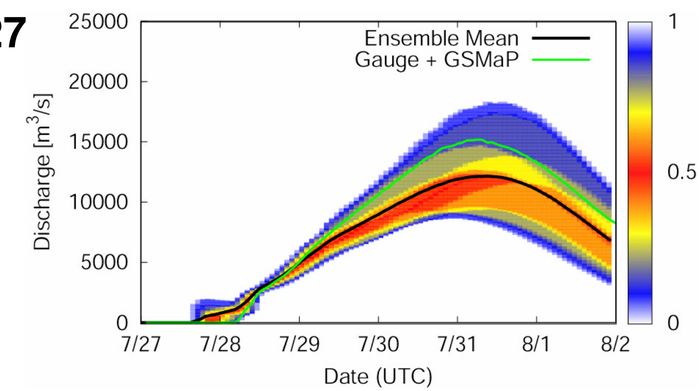
Input predicted rainfall of 13 members.

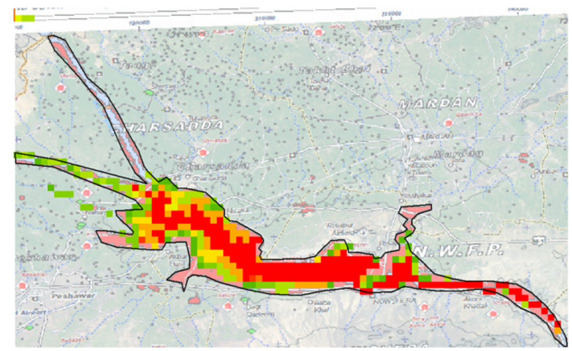


**Forecast at July 27**
**(24 00Z -27 00Z)**

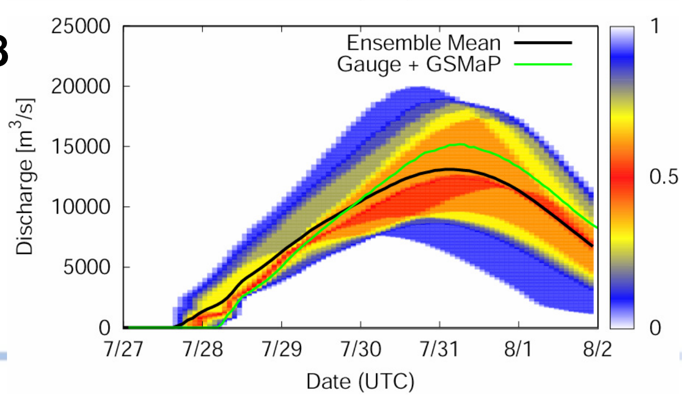
✓ Ensemble members with initial condition before the beginning of rainfall gave better ensemble mean and probability range.

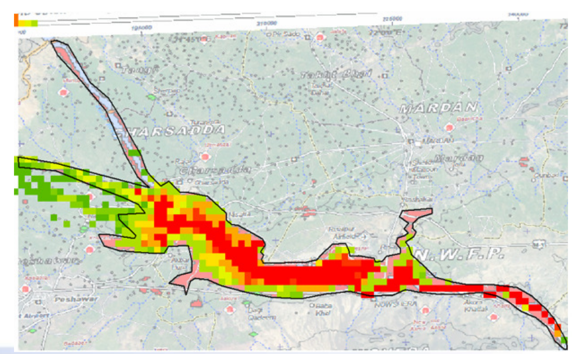


**Forecast at July 28**
**(25 00Z -28 00Z)**

✓ Ensemble members with their initial conditions during the rainfall period had large variance.



probability

- 0 – 0.1
- 0.1 – 0.2
- 0.2 – 0.3
- 0.3 – 0.4
- 0.4 – 0.5
- 0.5 – 0.6
- 0.6 – 0.7
- 0.7 – 0.8
- 0.8 – 0.9
- 0.9 – 1

Ushiyama et al. (2011)

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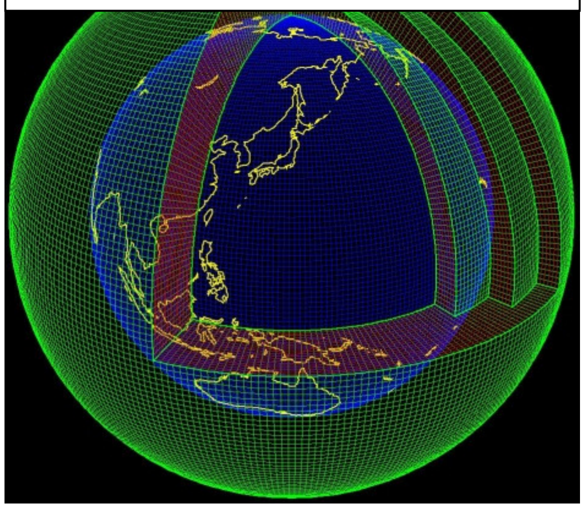
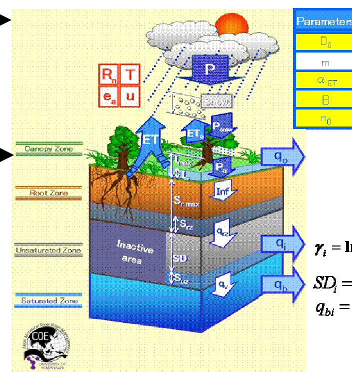
# Assessment of the impact of climate change on flood disaster risk and its reduction measures over the globe and specific vulnerable areas

10-40 km mesh
global stream path

MRI-AM20km global
meteorological simulation



Block-wise use of TOPMODEL with
Muskingum-Cunge method (BTOPMC)

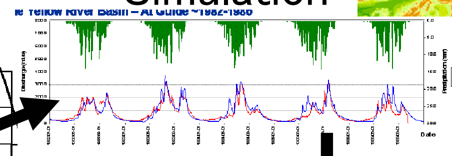


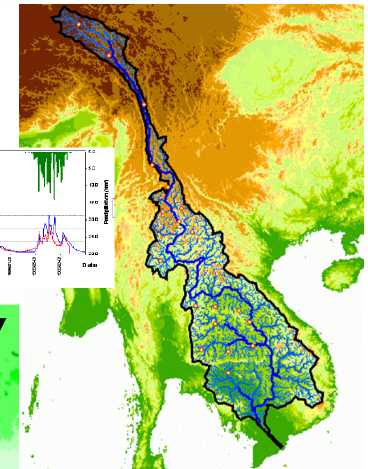

$\gamma_i = \ln \frac{a_i f(a_i)}{\tan \beta_i}$

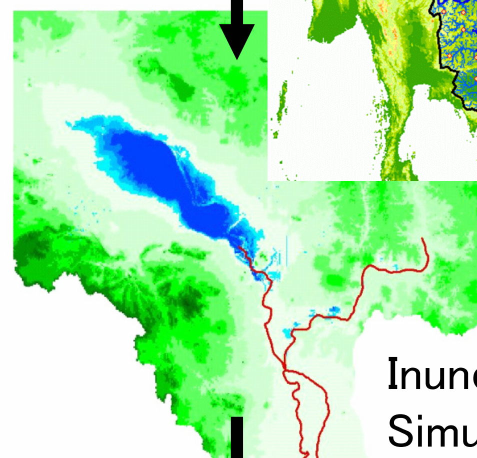
$SD_i = \overline{SD} + m(\gamma - \gamma_i - \ln \overline{D_0} - \ln D_i)$

$q_{bi} = D_{oi} \tan \beta_i \exp(-SD_i / m)$

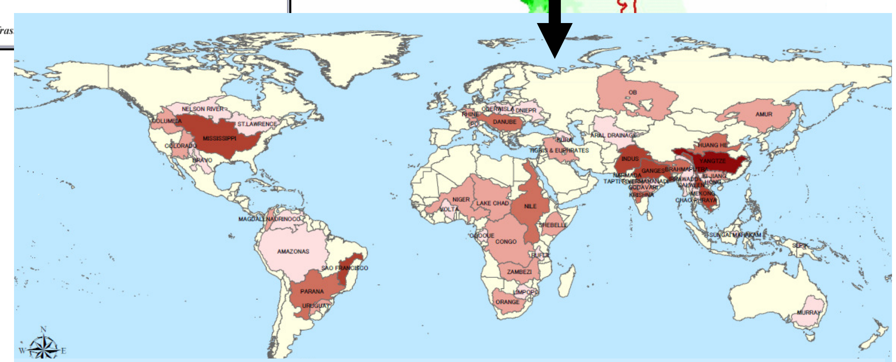
Hydrological
Simulation








Inundation
Simulation



Global Flood Vulnerable Risk Map

KAKUSHIN

Innovative Program of
Climate Change Projection
for the 21st Century

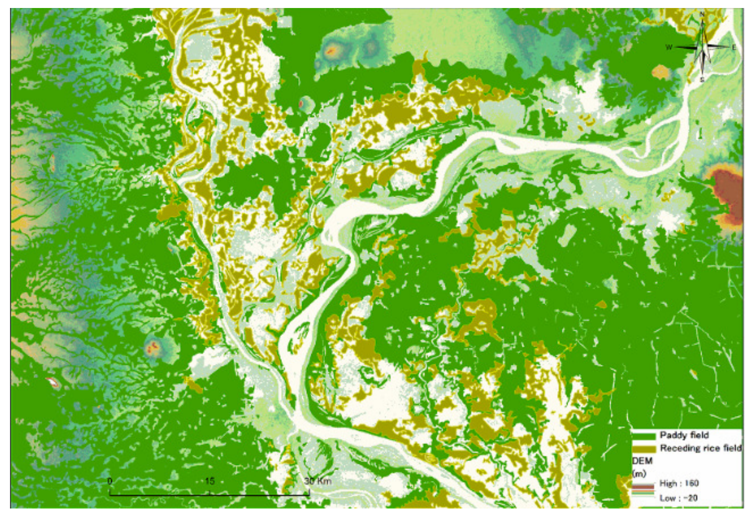
Project Period: 2007 Apr. – 2012 Mar.

# Effect of climate change on agricultural (rice) damage induced by flood

Nakasu et al. (2011)

| Total area of rice fields (thousand ha) | Ratio of each type of rice field (%) | | | |
|---|---|---|---|---|
| | Irrigated paddy field | **Rain-fed paddy field** | Upland rice field | Deep-water paddy field |
| 2,347 | 16 | **75** | 1 | 8 |

Kamoshita (2009)

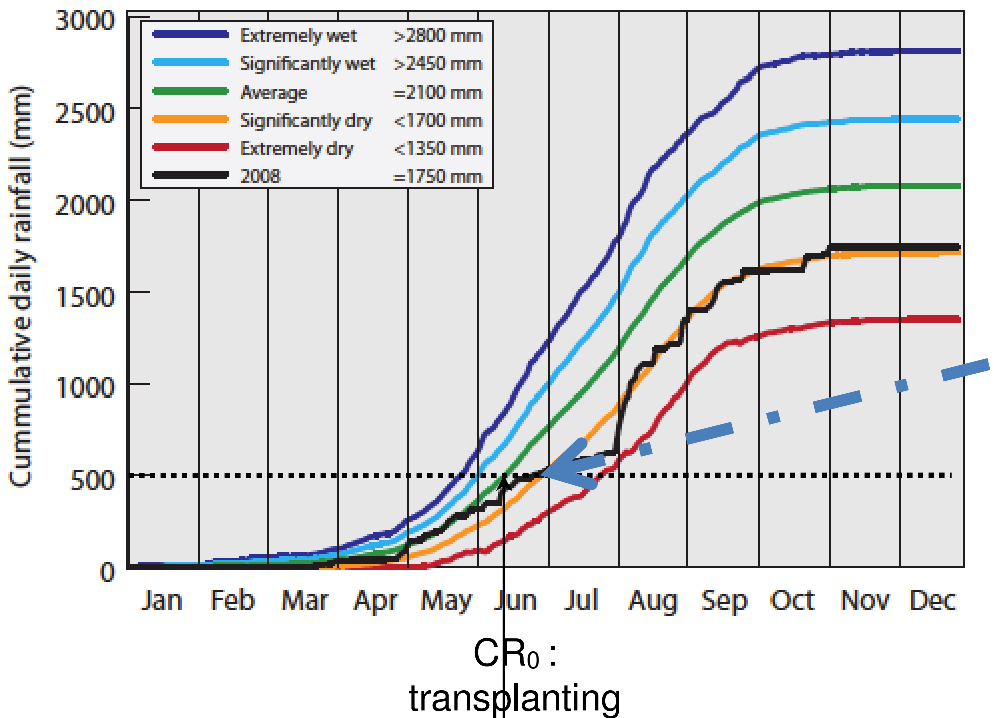




(MRC : FMMP data, 2010年)

Green: Rain-fed paddy field
Yellow: Flood-fed paddy field

Wet season rice in rain-fed paddy fields has high risk affected by the chage of rainfall and floods.

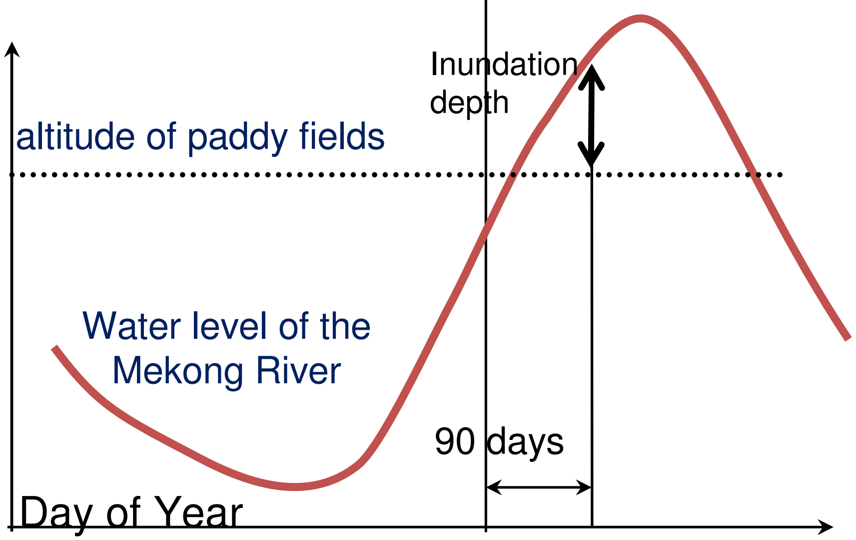
# Methodology to identify risk for rice production



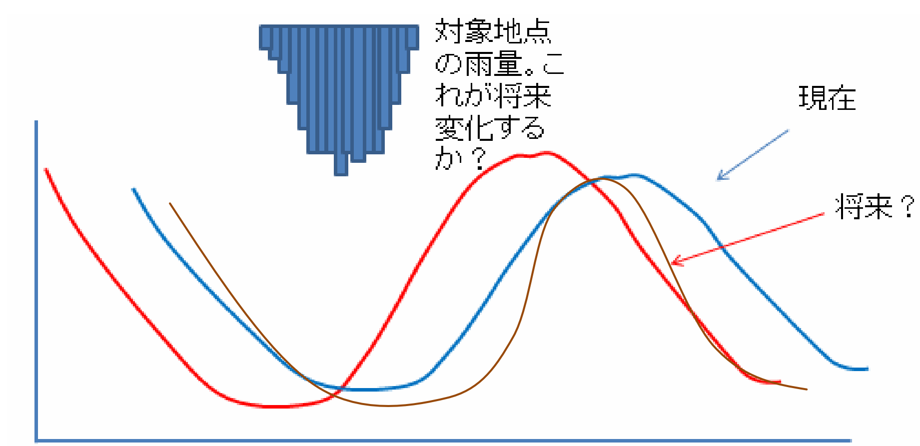

Relationship between planting and harvesting of rice
(wet-season rice, Cambodia)

**Planting date is the day when the cumulative rainfall from the beginning of a year reaches 500mm.**
**Growing period is about ninety days from the rice-planting.**
**Havesting date is assumed to be 90 days later than the planting date. (Masumoto et al.)**
**The occurrence and characteristics of rainfall before planting and floods during the growing period can have a significant effect of the production of rice.**

Nakasu et al. (2011)



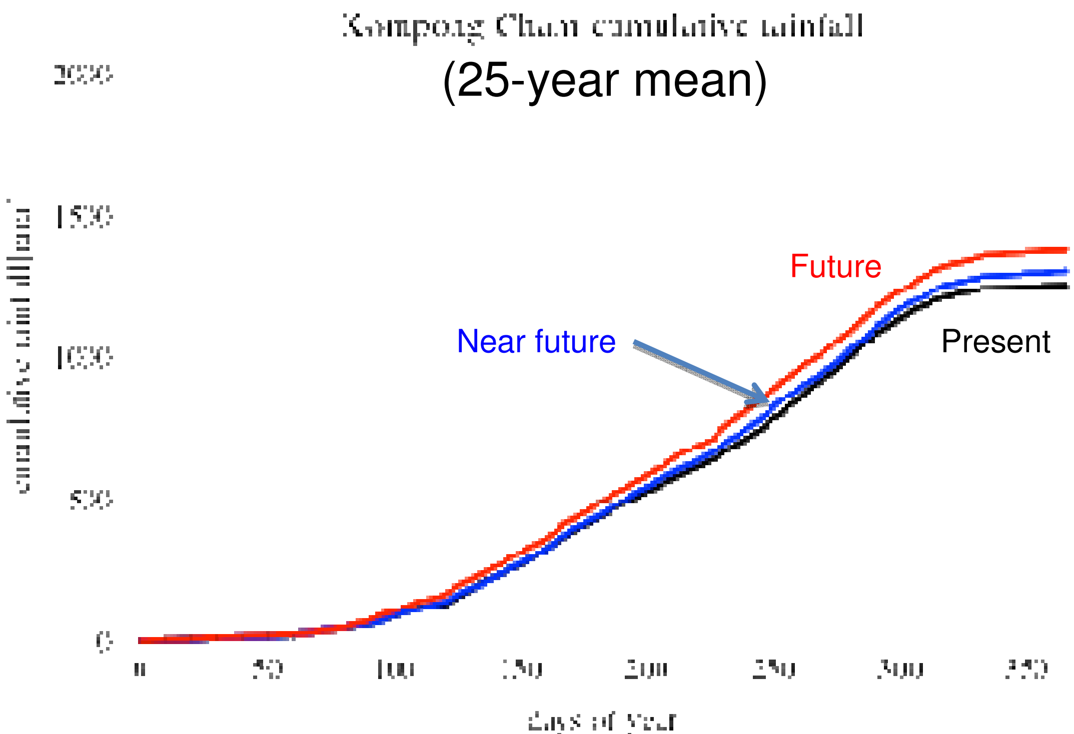

## Image of future risk

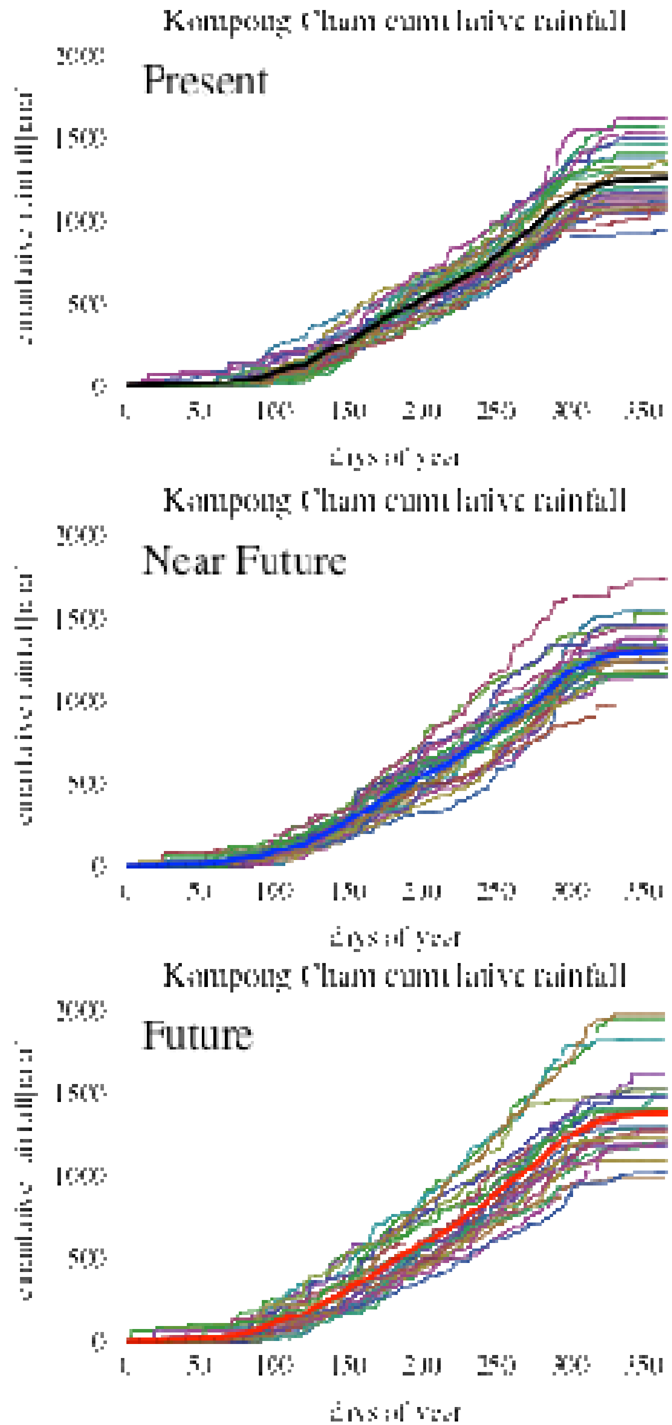


Variation of the cumulative rainfall from the beginning of a year in the Konpong Cham State

Based on MRI-AGCM3.1S

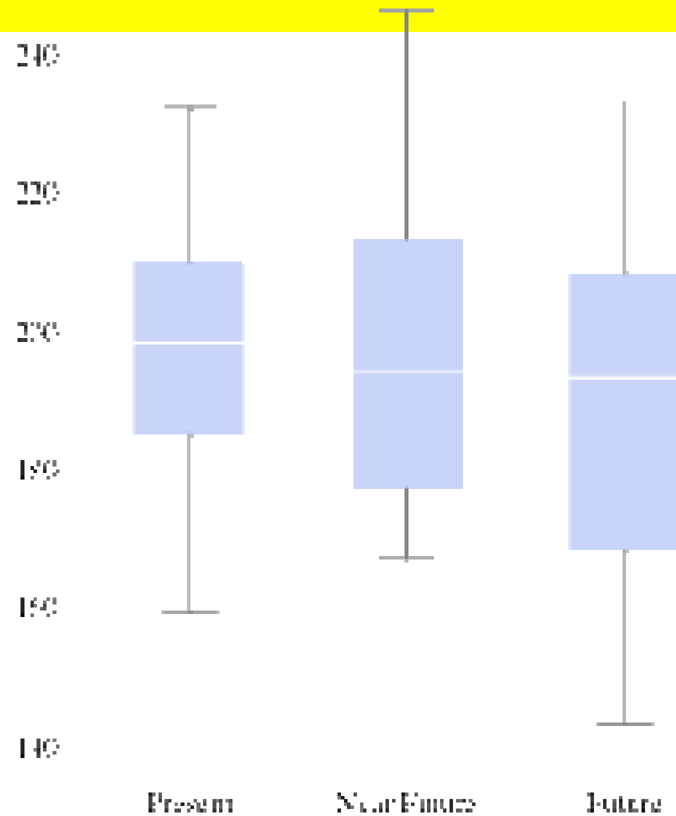
Nakasu et al. (2011)



# Variation of the date that the cumulative rainfall from the beginning of a year reaches 500 mm

| | Average | S.D. | Range |
|---|---|---|---|
| Present (1980-2004) | 198th | 20.1 | 73 days |
| Near future (2015-2039) | 196th | 22.3 | 79 days |
| Future (2075-2099) | 187th | 26.1 | 90 days |

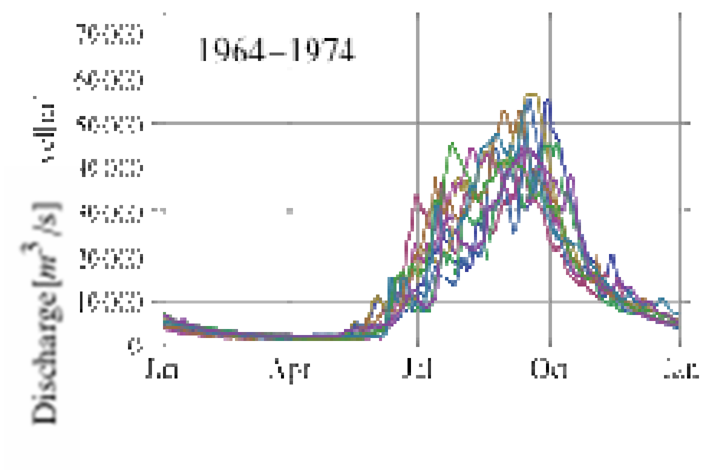


Nakasu et al. (2011)

**→ The date reaching 500mm may become earlier and more scattered.**

# Variation of river discharge

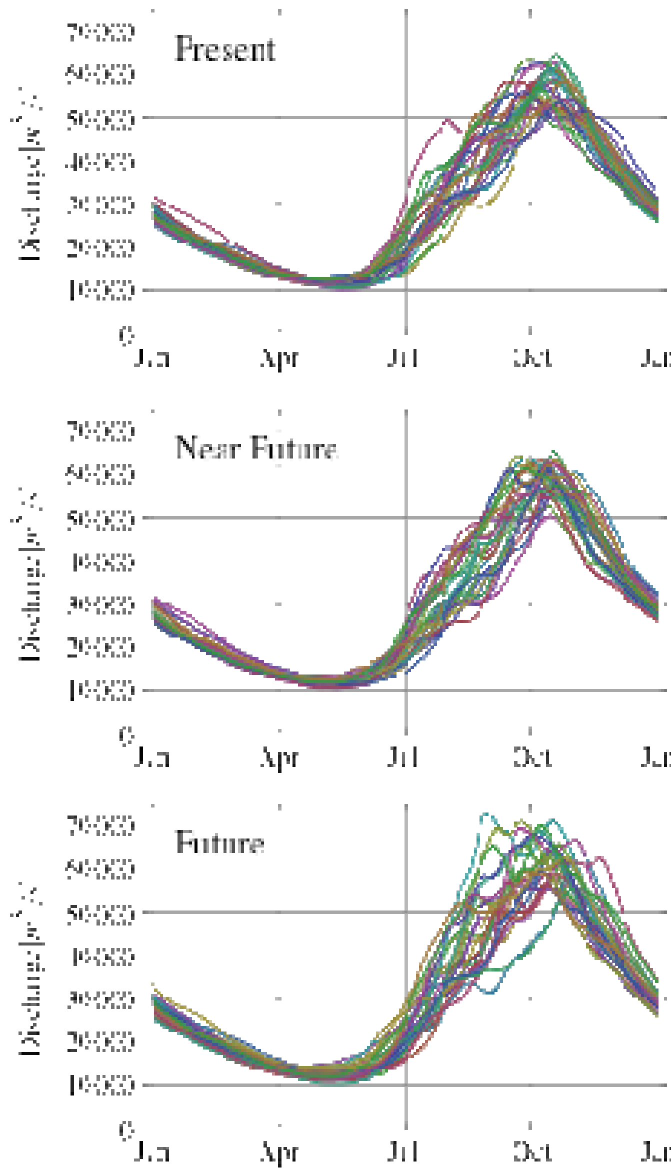
Based on MRI-AGCM3.1S and BTOP model



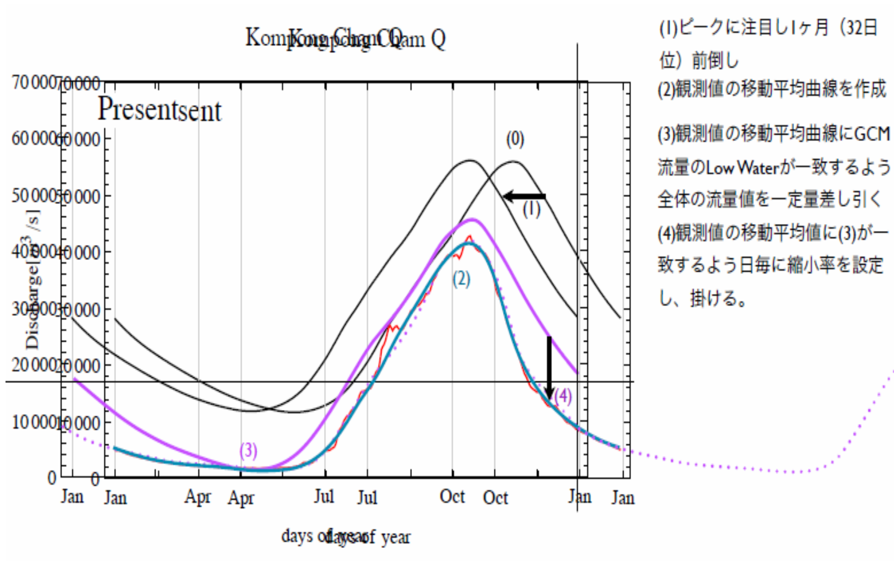

BTOP-simulation low flow is bigger than the observed for around 10,000m$^3$/s.
BTOP-simulation peak flood flow is also bigger for around 10,000m$^3$/s.
The recession of flood simulation is slower than the observed.

Nakasu et al. (2011)

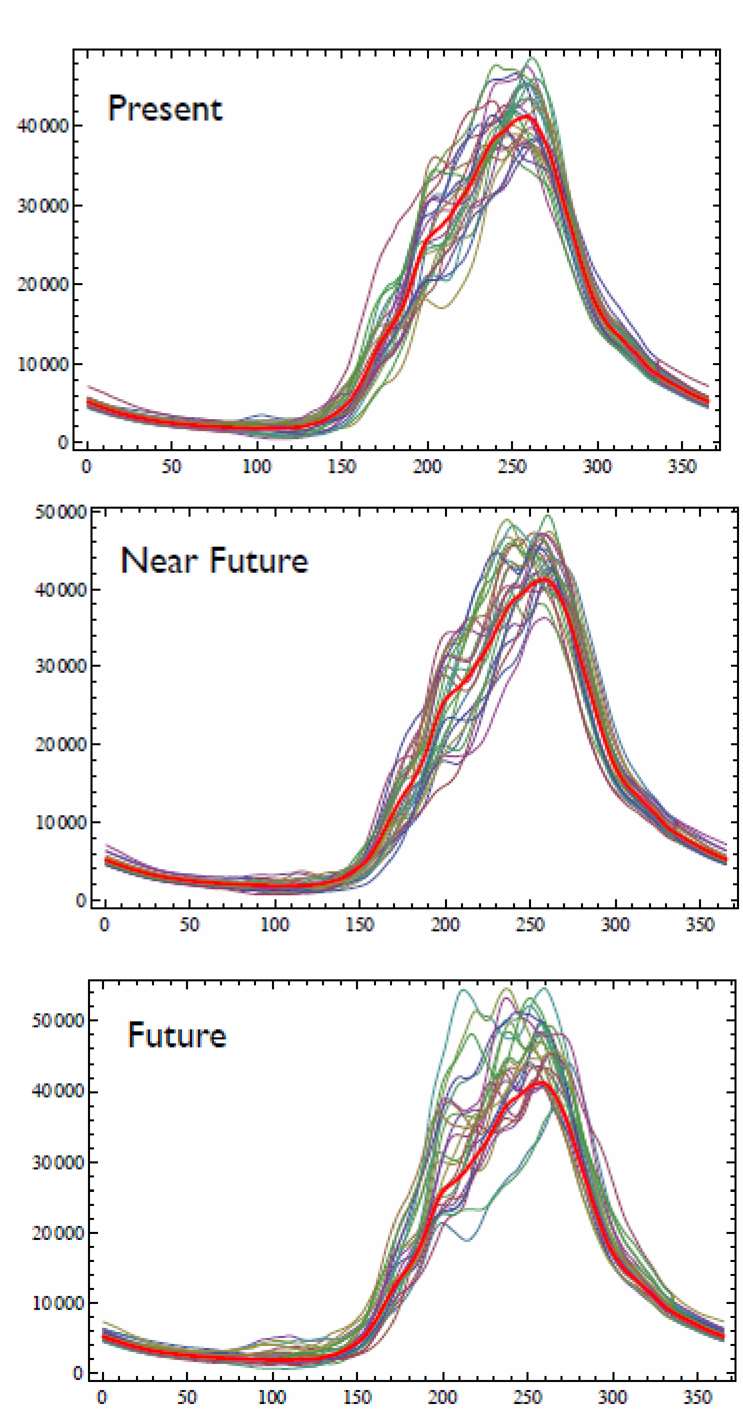
River flow discharge at Kompong Cham simulated with BTOP model



# Bias correction of BTOP runoff simulation




Nakasu et al. (2011)



# Variation of the date occurring annual maximum river discharge (before correction/bias-corrected)

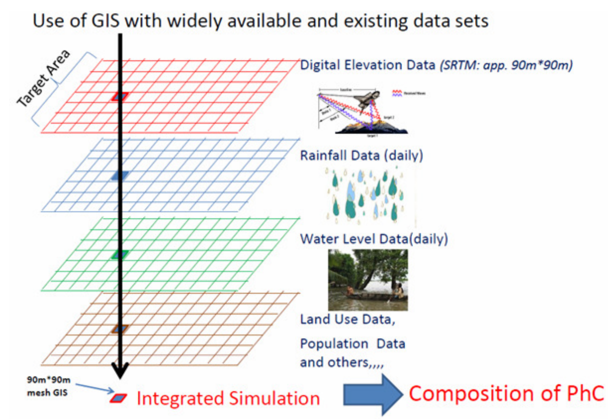
| Period | Mean Annual Max Q [$m^3/s$] | Mean Date of Annual Max Q | S.D. Date of Annual Max Q |
|---|---|---|---|
| Present (1980-2004) | 57600<br>42464 | 284.5th<br>254.5th | 10.2 days<br>8.2 days |
| Near future (2015-2039) | 59830<br>44523 | 285.5th<br>253.2th | 10.6 days<br>8.5 days |
| Future (2075-2099) | 63160<br>47119 | 284.6th<br>253.8th | 16.0 days<br>10.4 days |

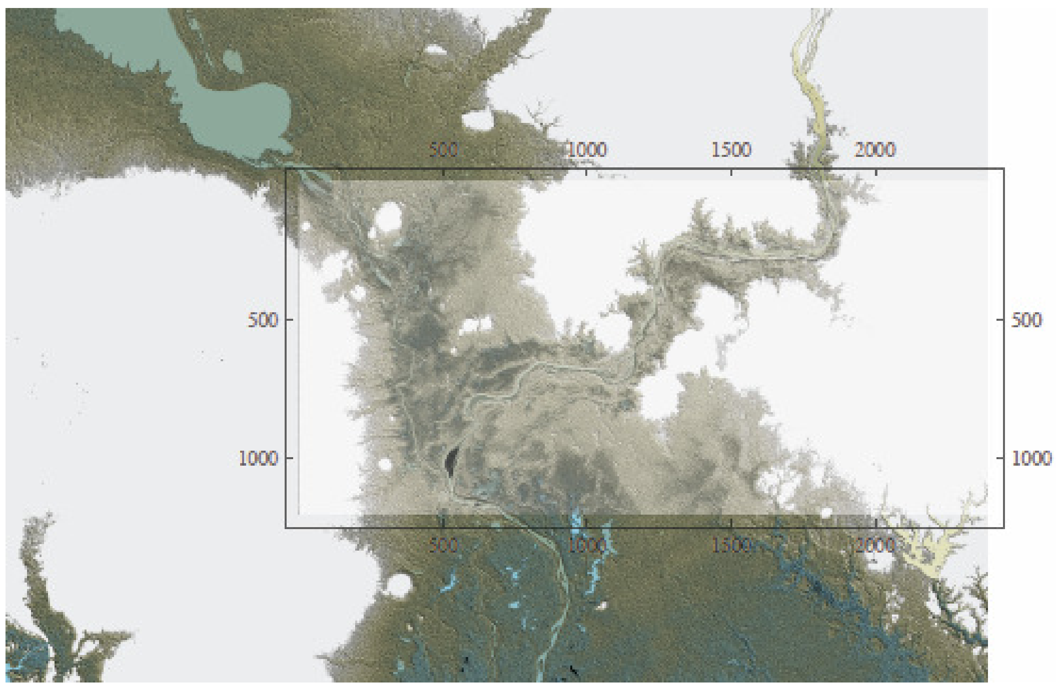
Nakasu et al. (2011)

**→ Annual maximum discharge may be increased.**
**Its occurrence day may not be changed on average,**
**but its variation may be enlarged.**

# Calculation of damage of rice production

Inundation depth and period were evaluated for each cell.



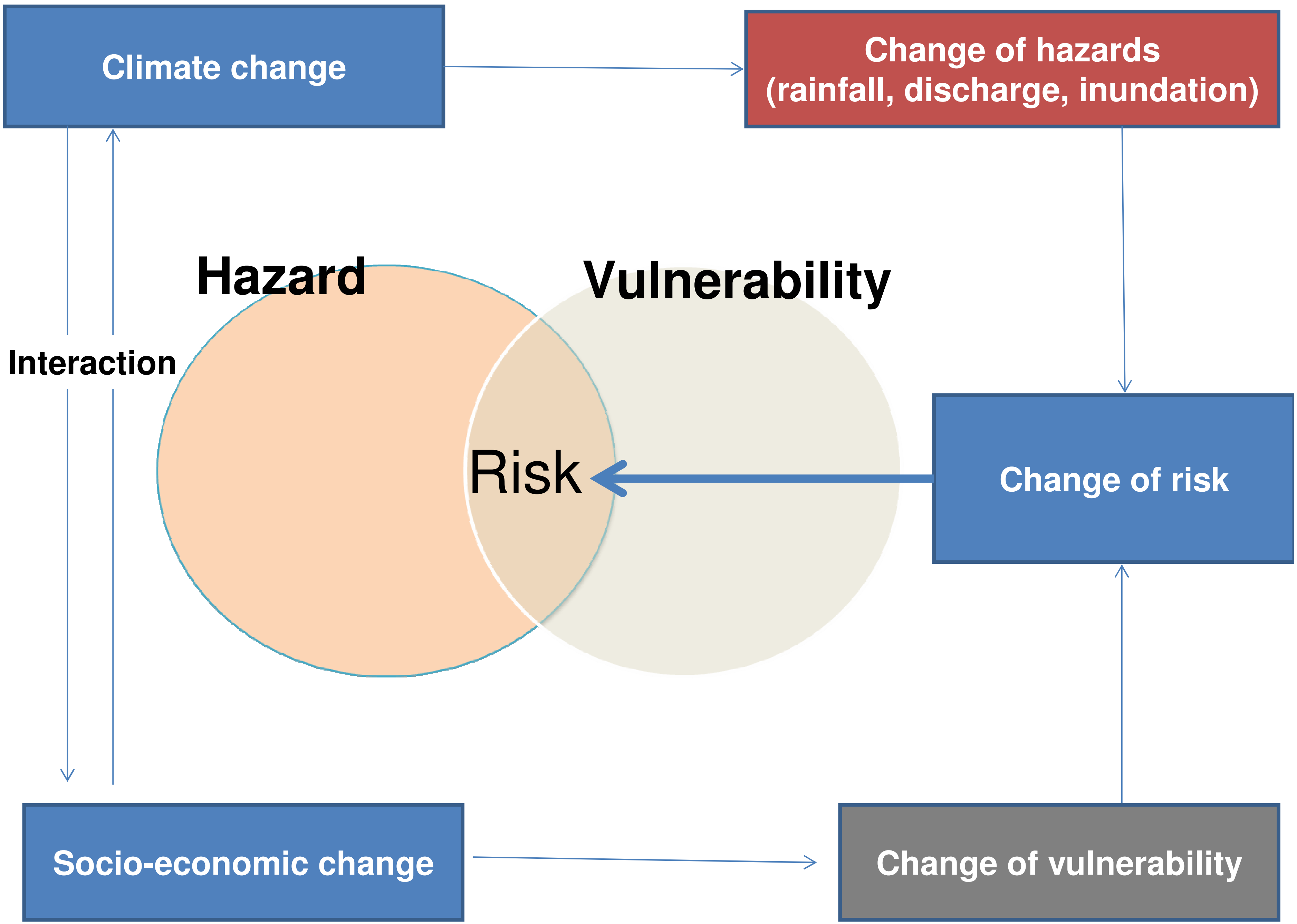

Nakasu et al. (2011)

# Evaluation of rice-production damage in the Kompong Cham

| | Mean annual damage | Standard deviation of annual damage |
|---|---|---|
| Present (1980-2004) | 11.1 M US $ | 15.1 M US $ |
| Near future (2015-2039) | 20.7 M US $ | 18.6 M US $ |
| Future (2075-2099) | 39.7 M US $ | 39.7 M US $ (2.6 times!) |

◆Damage estimation was based on the price of the export of rice from Thailand in 2010. The variation of price in the future was not considered.
◆Ref. GDP of Cambodia：10.8 billionUS$ (2009 , IMF)

Nakasu et al. (2011)


Climate change
Change of hazards
(rainfall, discharge, inundation)
Hazard
Vulnerability
Interaction
Risk
Change of risk
Socio-economic change
Change of vulnerability

# Socio-economic change outlook
# (SRES Scenario A1 downscaled data by SEDAC)

**Population**

| 2010(A1) | 2050(A2) | 2100(A3) |
|---|---|---|
| 16,012,549 | 23,823,884 | 12,403,112 |

**Ratio of change** **A2/A1=1.49** **A3/A1 = 0.77**

**GDP**

| 2010(B1) | 2050(B2) | 2100(B3) |
|---|---|---|
| 5,935,102,970 | 73,341,510,176 | 186,912,383,301 |

**Ration of change** **B2/B1=12.4** **B3/B1 = 31.5**

Source: http://sedac.ciesin.columbia.edu/

**Since the change of socio-economic outlook is relatively big, the effect of uncertainties of socio-economic outlook can be much bigger than that of physical hazard prediction.**


Thank you for your attention!