Introduction of ongoing studies at ICHARM

- Some implications to the GEOSS-AWCI Next Stage -

Kazuhiko FUKAMI

International Centre for Water Hazard and Risk Management under the auspices of UNESCO (UNESCO-ICHARM),
Public Works Research Institute (PWRI), Japan

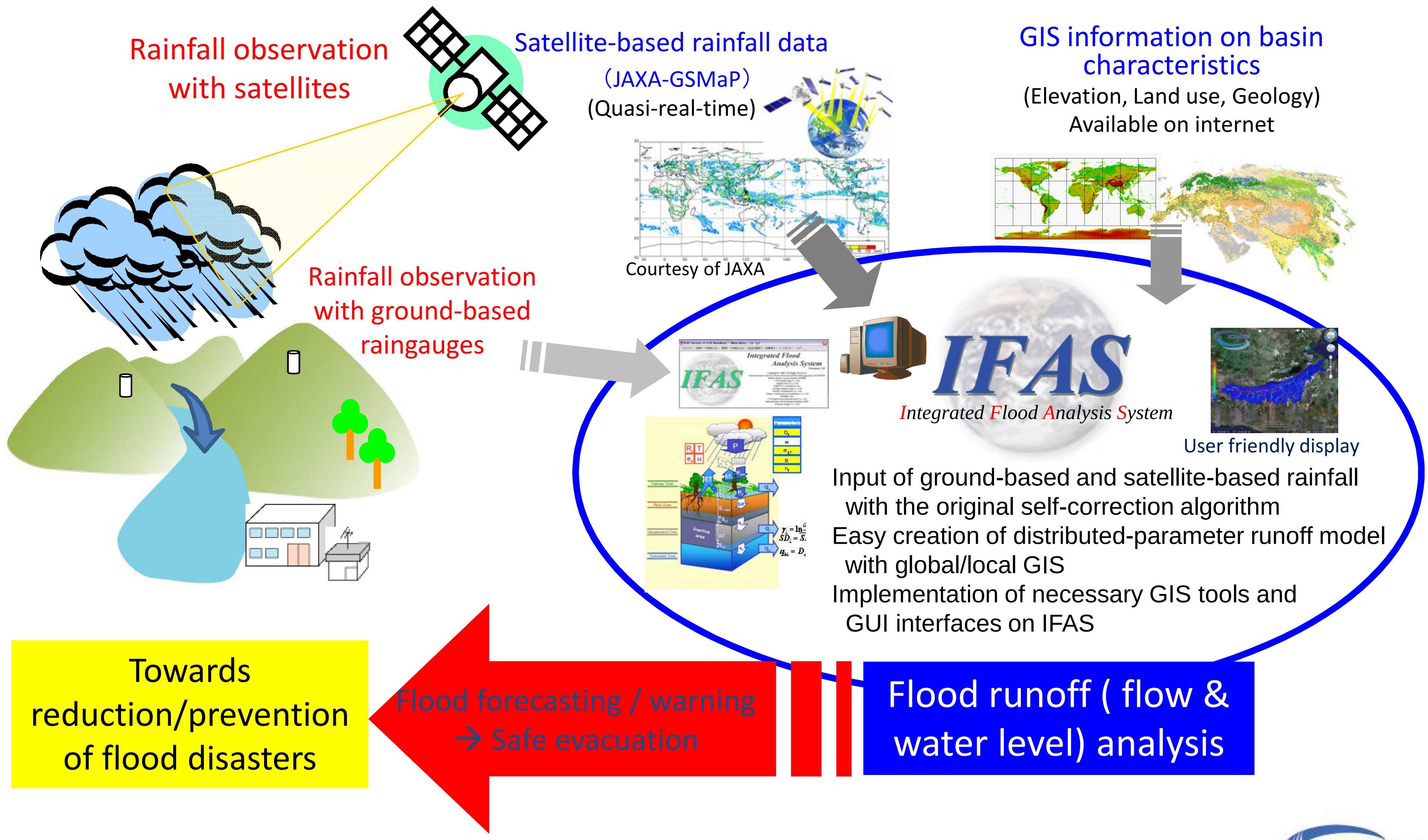
IFAS

IFNet International Flood Network

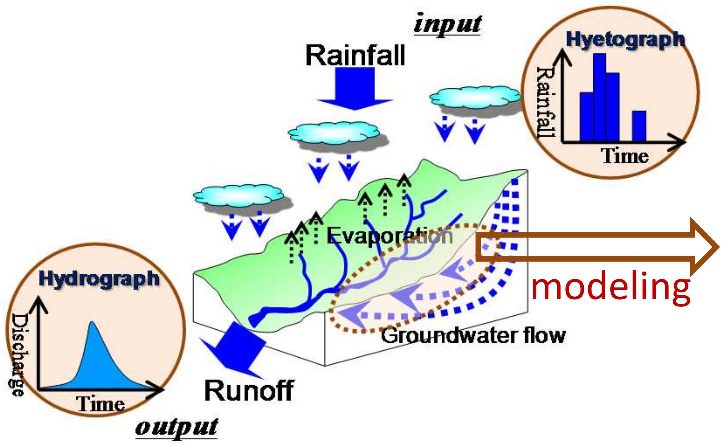
ICHARM

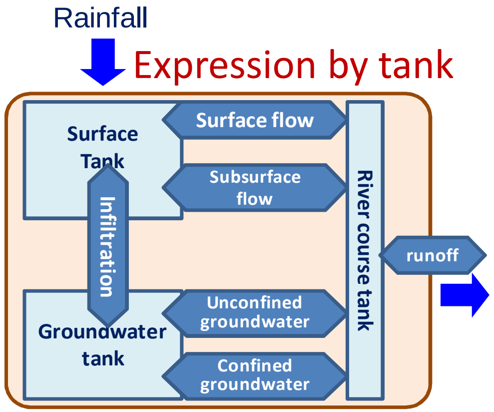
Integrated Flood Analysis System (IFAS)

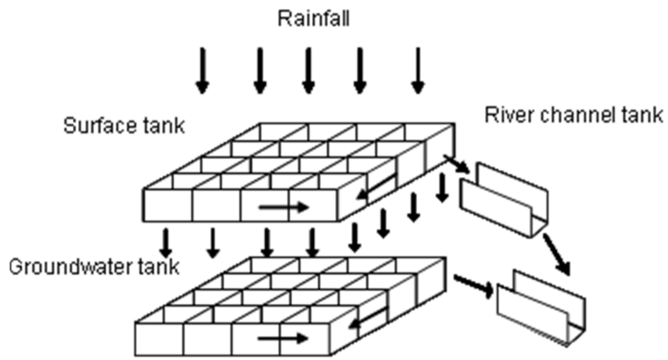
Flood runoff analysis system with satellite-based rainfall & global GIS information



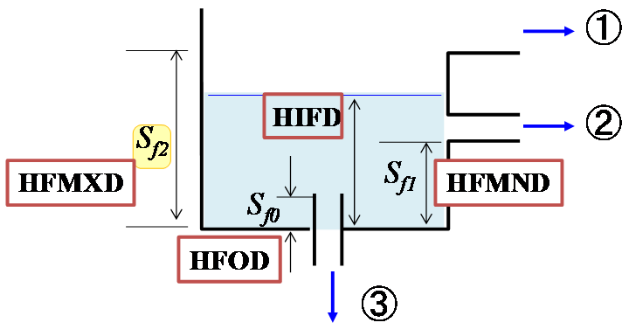
Runoff Analysis Model on IFAS (PDHM Ver.2)







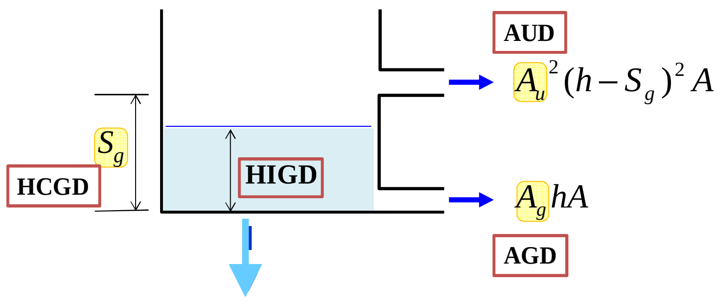
Surface Tank (Upper tank)	Groundwater Tank (Lower tank)	River Course Tank



①Surface flow: $L\frac{1}{N}(h-S_{f_2})^{\frac{5}{3}}\sqrt{i}$ SNF

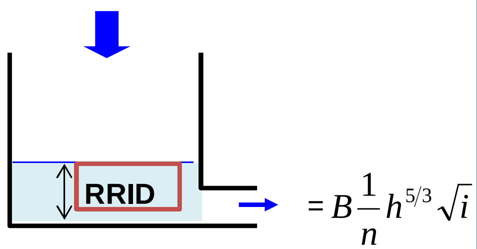
②Subsurface flow: $\alpha_n A f_0(h-S_{f_1})/(S_{f_2}-S_{f_1})$ FALFX

③Infiltration: $Af_0(h-S_{f_0})/(S_{f_2}-S_{f_0})$ SKF



It is possible to set α as groundwater loss.

Parameters of upper tank varies by land cover (forest, bush and meadow, cropland



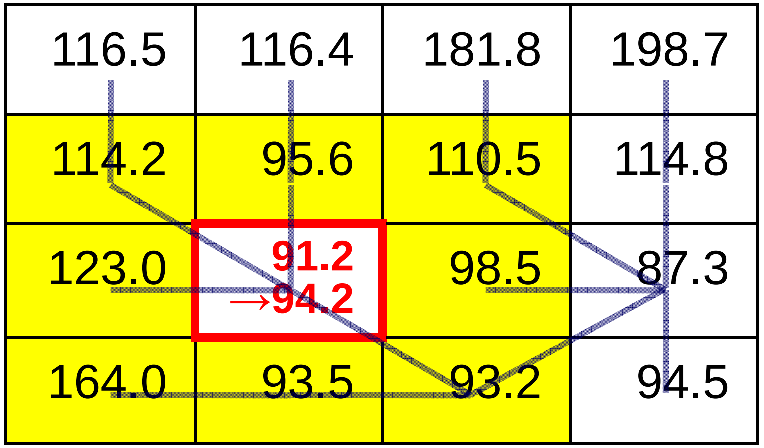
Even if you have no cross-section data of river channels, it is possible to calculate flood flow in steep river channels through the Manning Formula with the assumption or wide rectangular channels.

Flood runoff simulation model creation using global GIS data

Import data

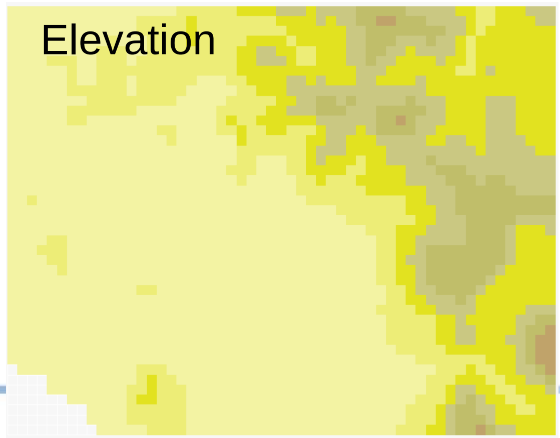
Type	Product	Provider
Elevation	Global Map(Elevation data)	ISCGM
	GTOPO30	USGS
	Hydro1k	USGS
Land use	GLCC	USGS
	Global Map(Land cover)	ISCGM
	Global Map(Land use)	ISCGM
Geology	Geology	CGWM
Soil type	Soil Texture	UNEP
	Soil Water Holding Capacity	UNEP
	Soil Depth	GES

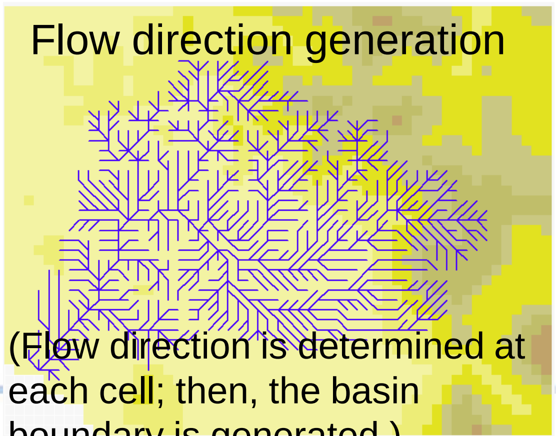
Example of elevation data of a each cell and a river channel network



Modify elevation until all sells are decided their flow directions

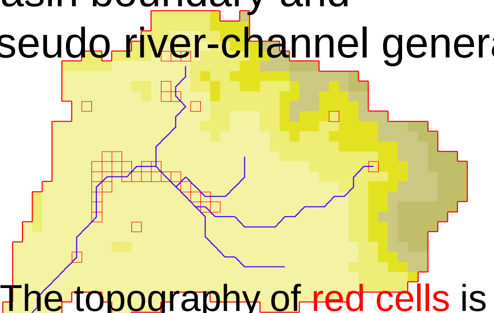
Creation of River channel network and basin shape based on elevation data





(Flow direction is determined at each cell; then, the basin boundary is generated.)

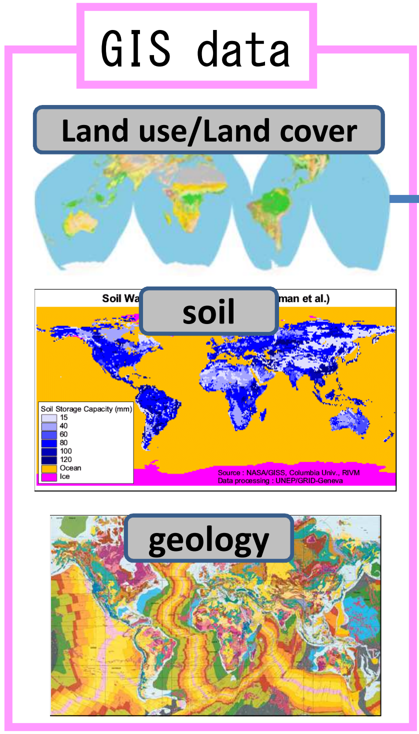
Basin boundary and pseudo river-channel generation

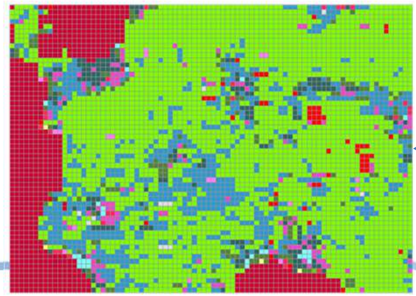


(The topography of red cells is automatically corrected for flow direction generation.)

Parameter estimation using GIS data [surface / groundwater

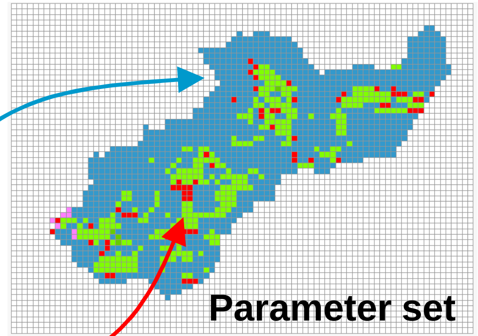
1. Import GIS data → 2. Distribute GIS data into some classes → 3. Input value for each tank → 4. Set value for each cell





Imported GIS data

Land use classification (GlobalMap)	Surface parameter	Infiltration capacity	Rough -ness	○○
Broadleaf Evergreen Forest	1	0.0005	0.7	…
Broadleaf Deciduous Forest				
Needleleaf Evergreen Forest				
Needleleaf Deciduous Forest				
Mixed Forest				
Tree Open				
Shrub	2	0.00002	2	…
Herbaceous				
Herbaceous with Sparse Tree/Shrub				
Sparse vegetation				
Bare area (gravel, rock)				
Bare area (sand)				
Cropland	3	0.00001	2	…
Paddy field				
Cropland / Other Vegetation Mosaic				
Mangrove				
Wetland				
Urban	4	0.000001	0.1	…
Snow, ice	5	0.00001	2	…
Water bodies				



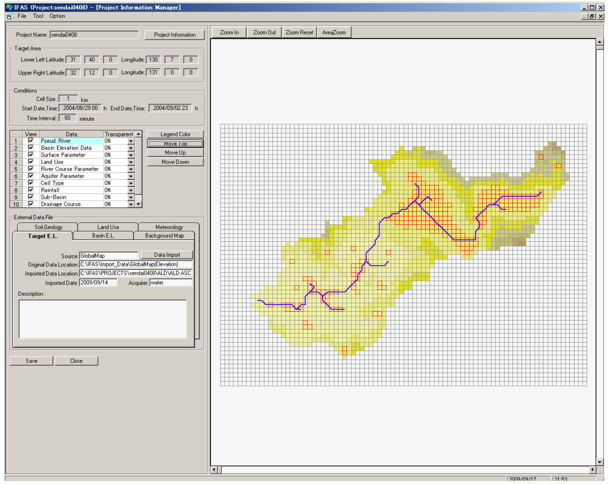
Parameter set

- ◆IFAS has already set default parameter.
- ◆Each parameter reflects local condition.

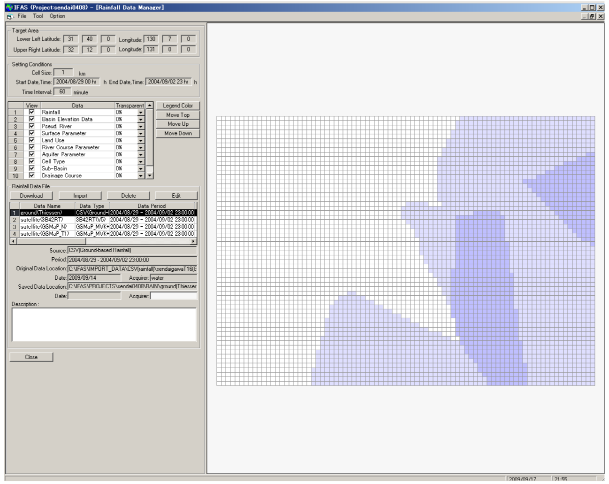
ICHARM

Interface display

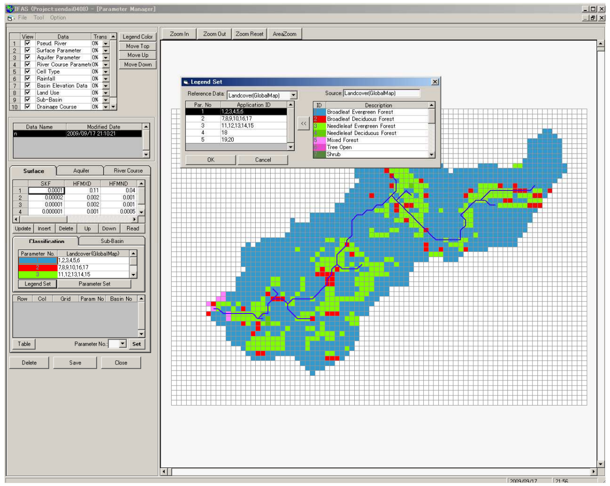
Main display



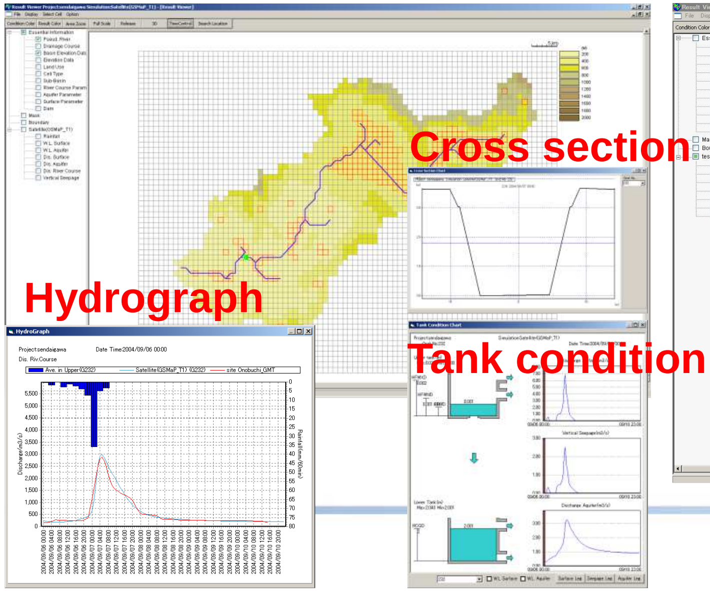
Edit display of rainfall data



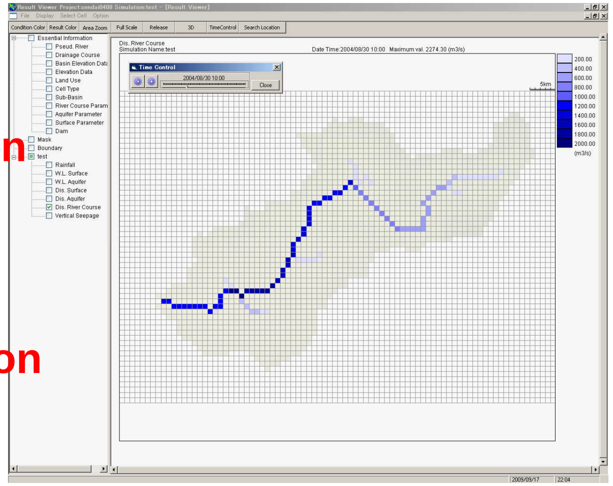
Setting display of parameter



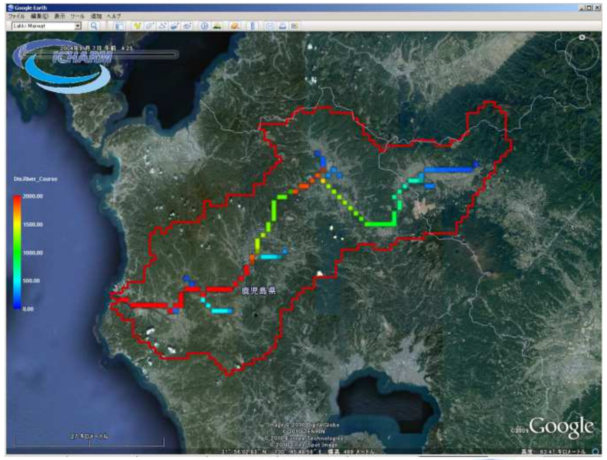
Calculation result



Calculation (Plane view)

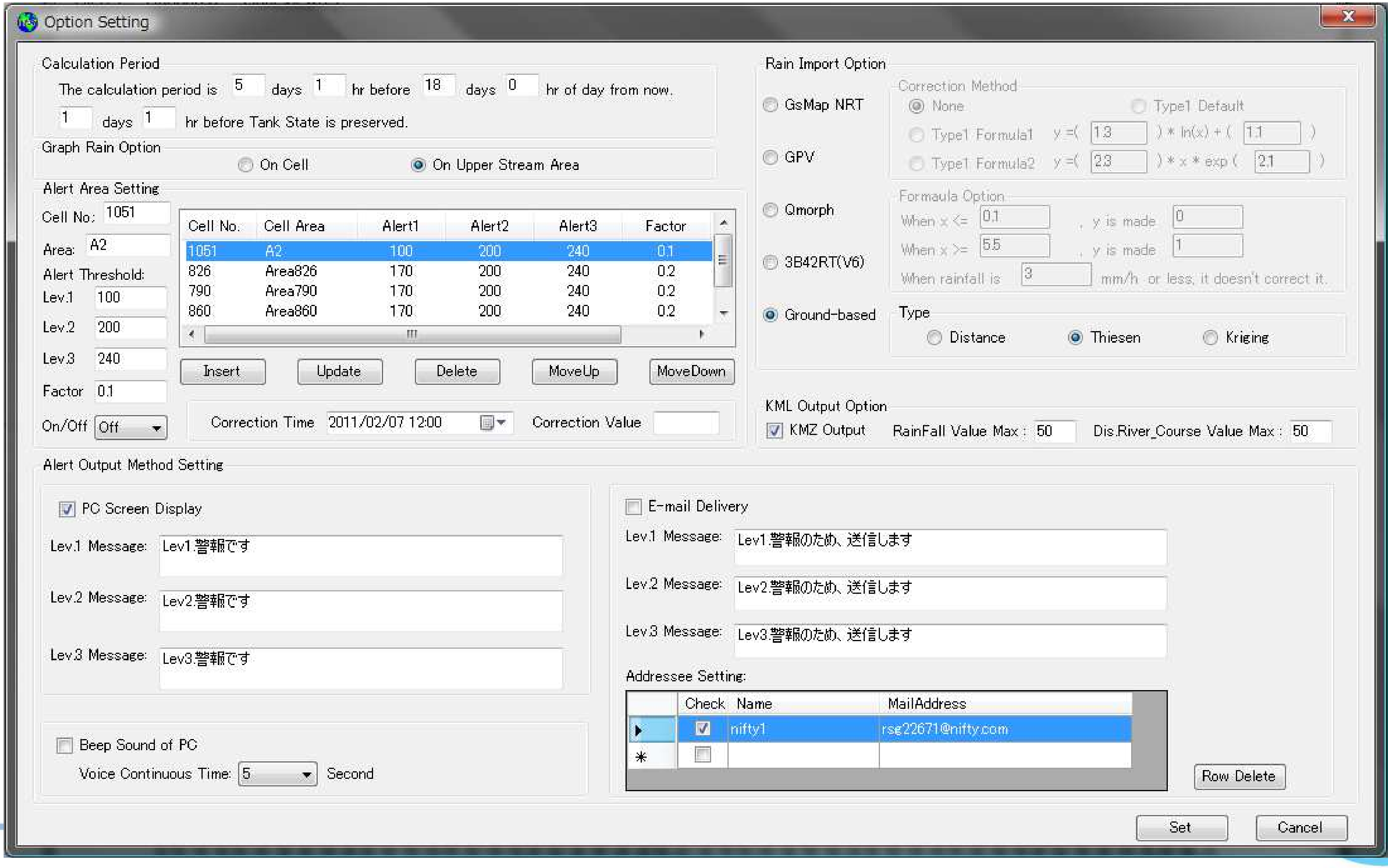


Plane view on Google Map



New IFAS-extra-module for Automatic Warning System (IFAS Ver.1.3)

(automatic incremental simulation for each time step and alert window & e-mail)



IFAS Training workshops (2008 – 2011)

- Purpose of the training course

  To build capacities to undertake hydrological analyses/forecasting in relatively ungauged basins through coupled usage of global / insitu data.

Program

•Remote Sensing of Precipitation from Space (JAXA)
•Introduction of river administration in Japan
•Introduction of Global Flood Alert System
•Operating procedures for IFAS
•Validation method of satellite-based rainfall
•Current conditions and problems in each country

- International Workshop on Application and Validation of GFAS

  2008: Ethiopia, Zambia, Cuba, Argentina, Bangladesh, Guatemala, Nepal (7countries)

  2009: India, Indonesia, Viet Nam, Bangladesh, Nepal, Laos (6countries)

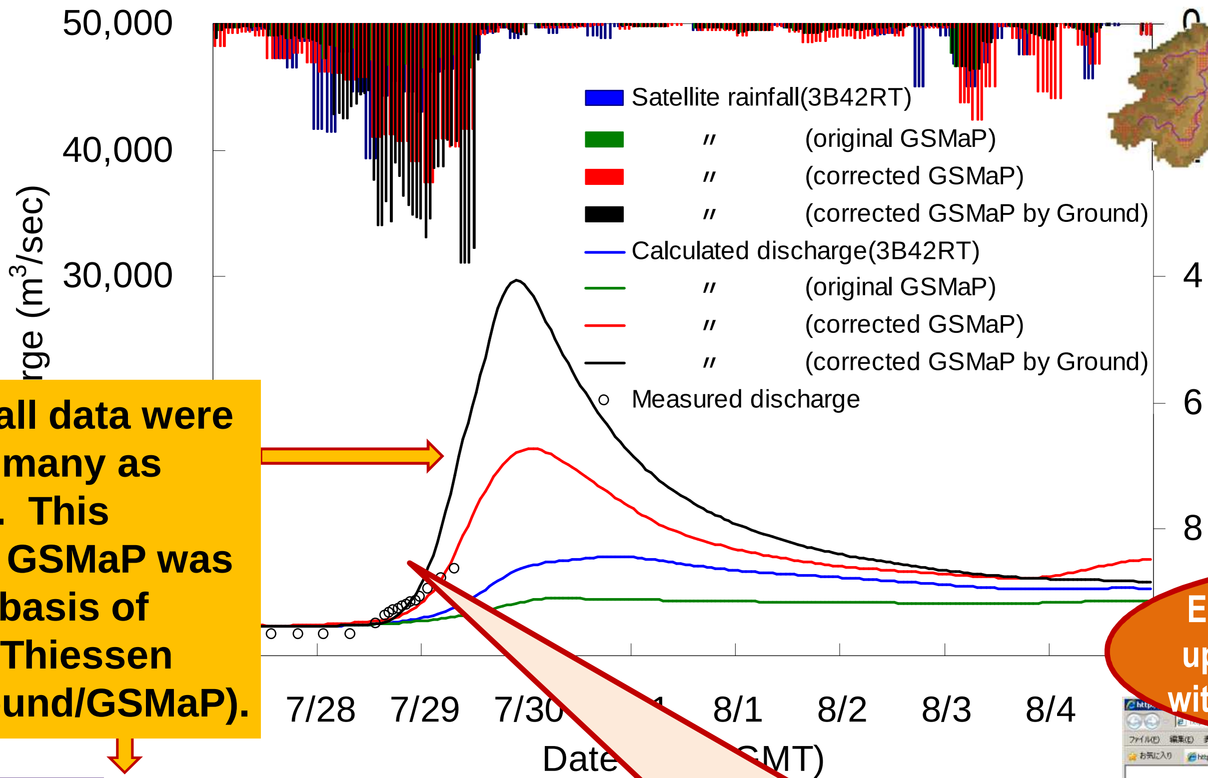
- IFAS Seminars in overseas (sponsored by ADB, JAXA, UNESCAP, etc.)

  Nepal (2009), Indonesia, Myanmar, Vietnam (2010),

  Pakistan, Thailand, and India (2011)

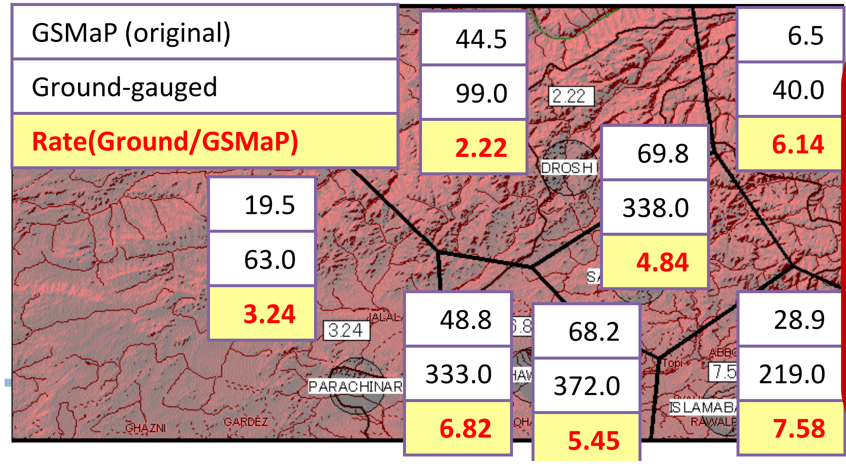
- ICHARM PhD & Master Courses, JICA short courses, etc.

IFAS-based runoff analysis: Kabul River, Pakistan



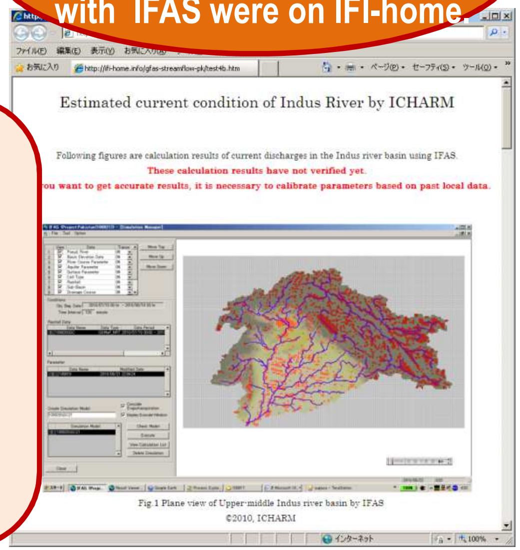
Calculated by Default parameter

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).



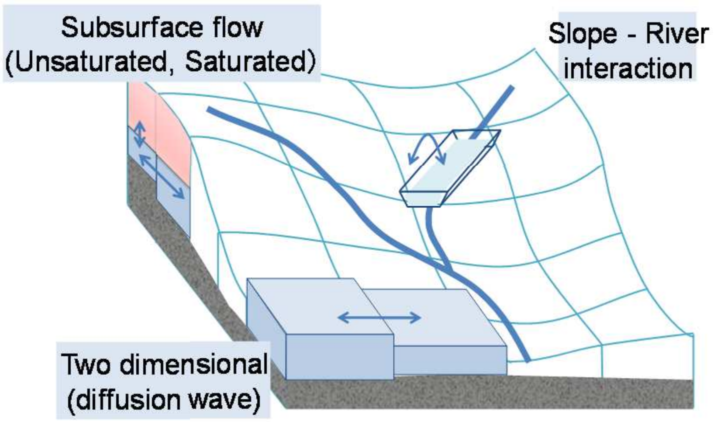
Alghouth the runoff simulation with ICHARM's self-correction algorithm without any ground-based rainfall data seemed best, this does not necessarily mean the truth. In any case, this shows the high potential of satellite-based runoff simulation.

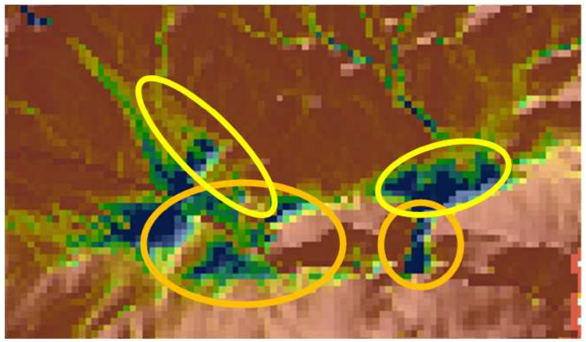
Estimated hydrographs in upper & middle Indus river with IFAS were on IFI-home



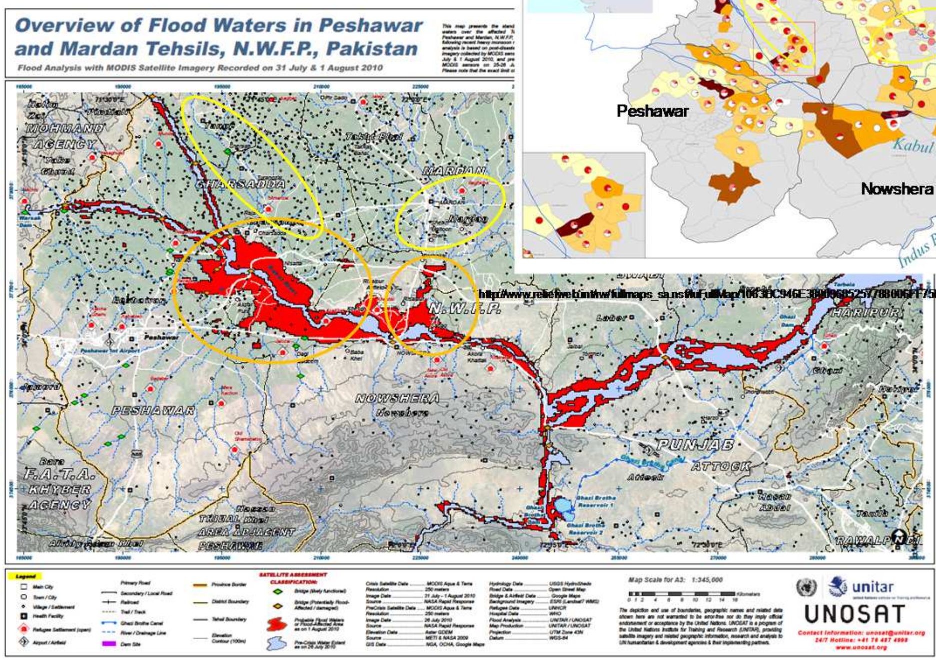
Comparison between satellite-based inundation extent and inundation simulations with another ICHARM's Rainfall-Runoff-Inundation (RRI) Model for Pakistan flood, August 2010

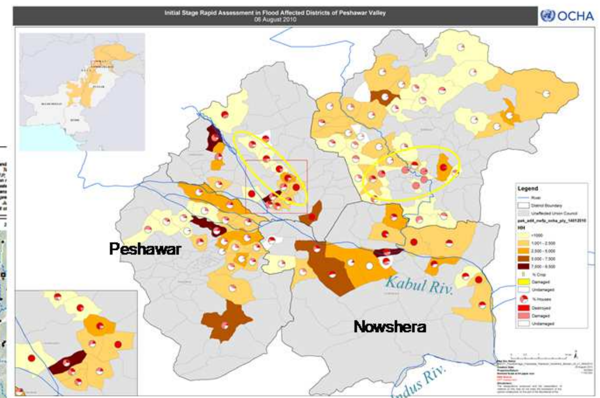
Runoff-inundation simulation can **interpolate <u>missing</u> satellite-based information** on flood inundation area caused by flash flood.





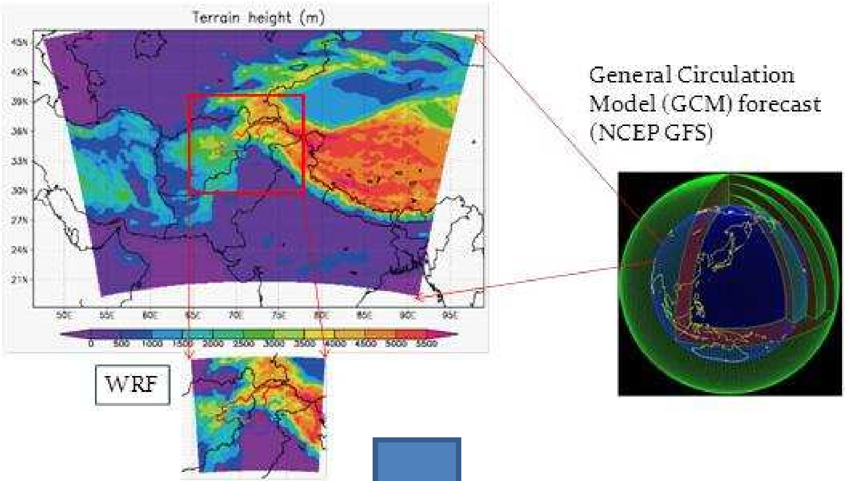
Sayama et al. (2011)

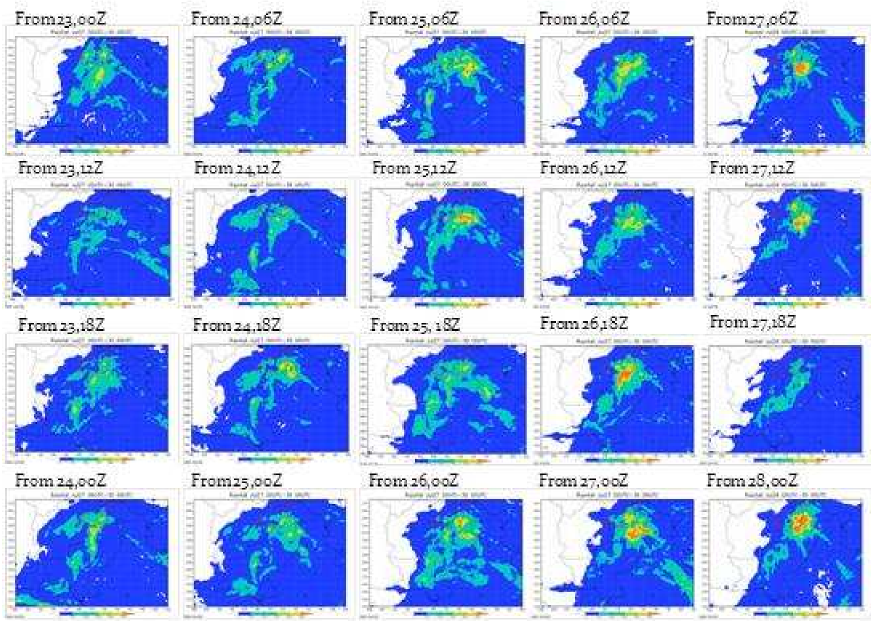


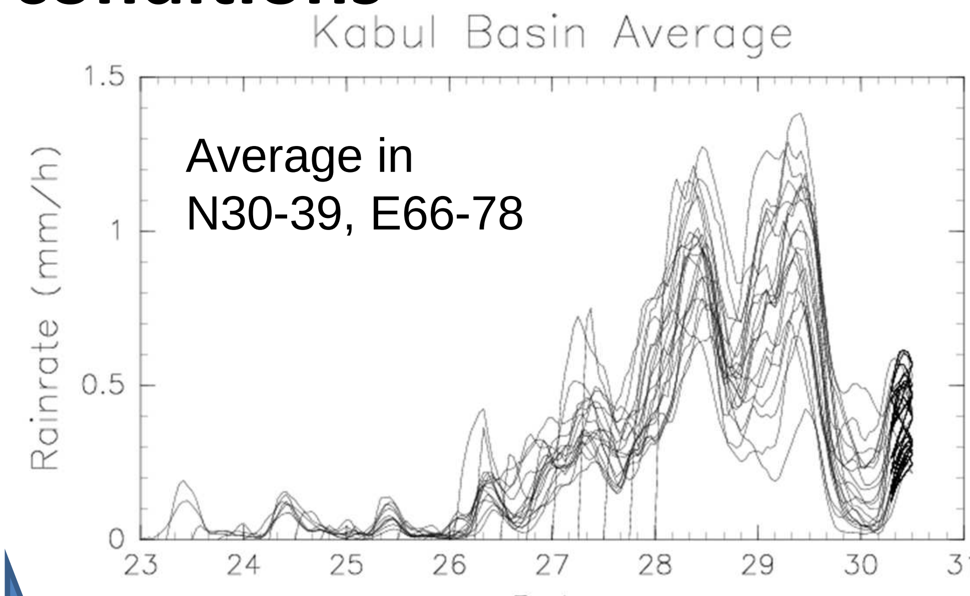


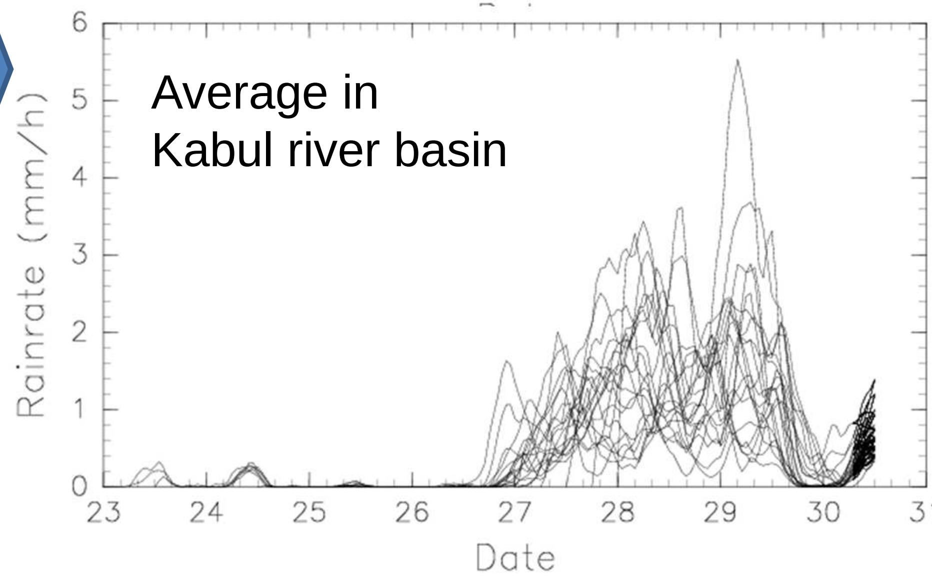
Rainfall downscaling & forecasting with different initial conditions

Ushiyama et al. (2011)





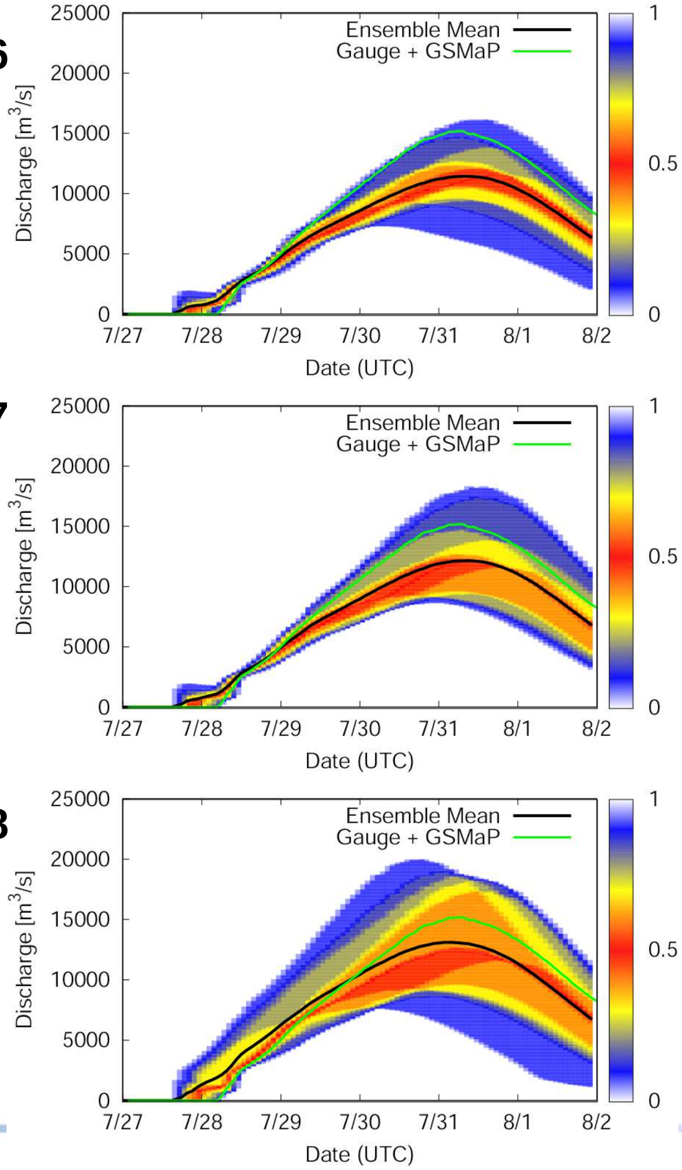




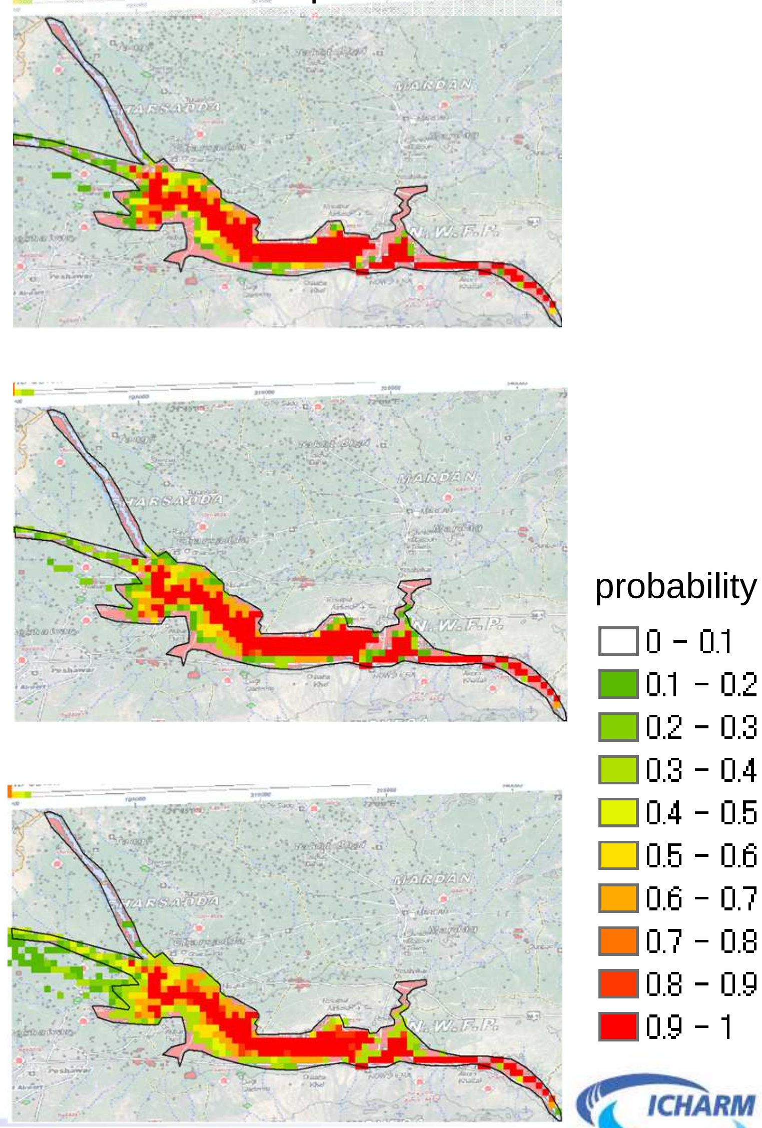
Ensemble of rainfall forecast with WRF

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)

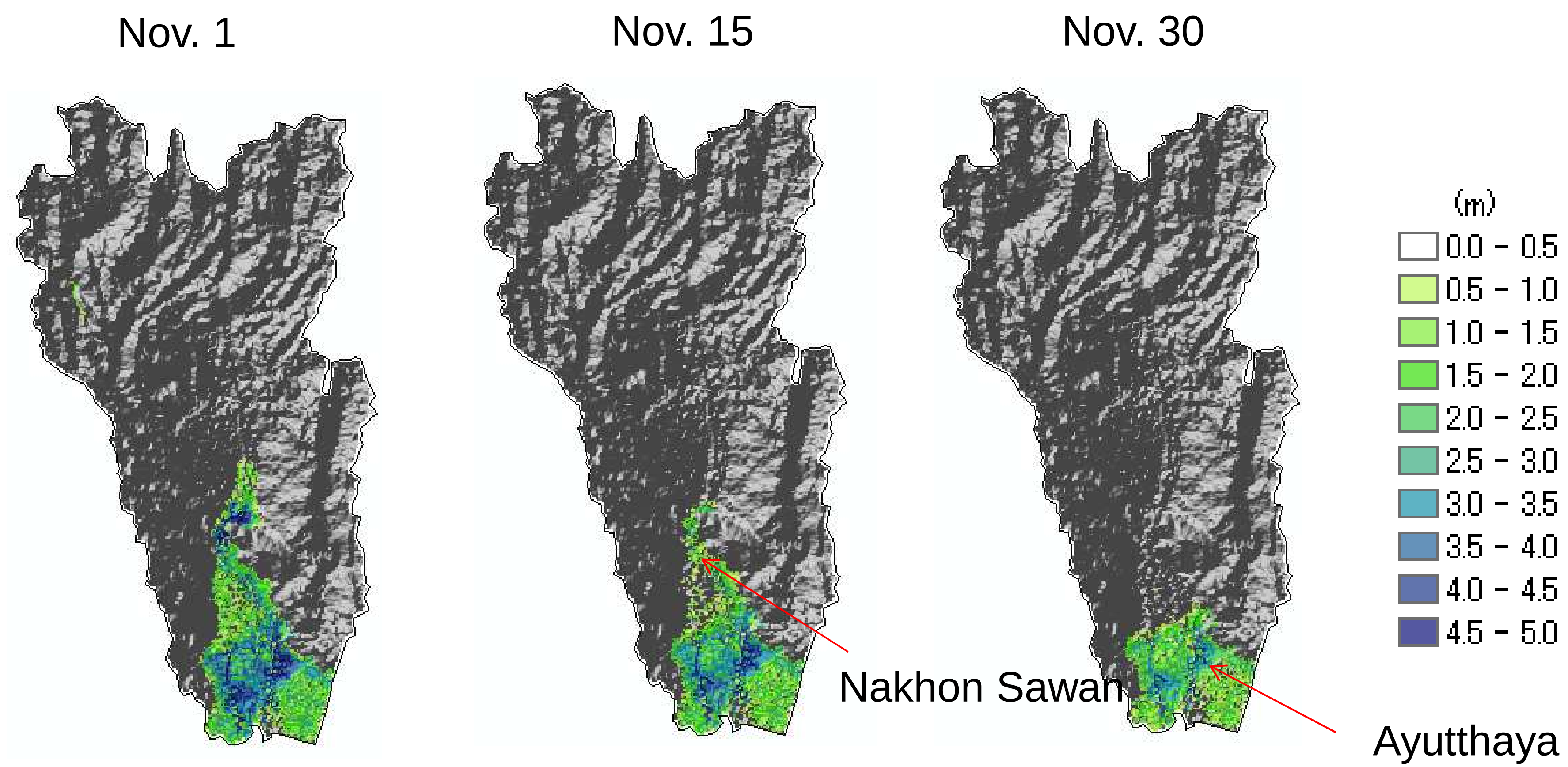
✓ Ensemble members with initial condition before the beginning of rainfall gave better ensemble mean and probability range.

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

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

Ushiyama et al. (2011)

Rainfall-Runoff-Inundation model simulation for Thai Flood, 2011



- At Nov. 1, flooding still remains high around the Nakhon Sawan and Ayutthaya
- At Nov. 15, flooding around the Nakhon Sawan is reduced
- At Nov. 30, the flooding remains only partially at the northern part of Bangkok

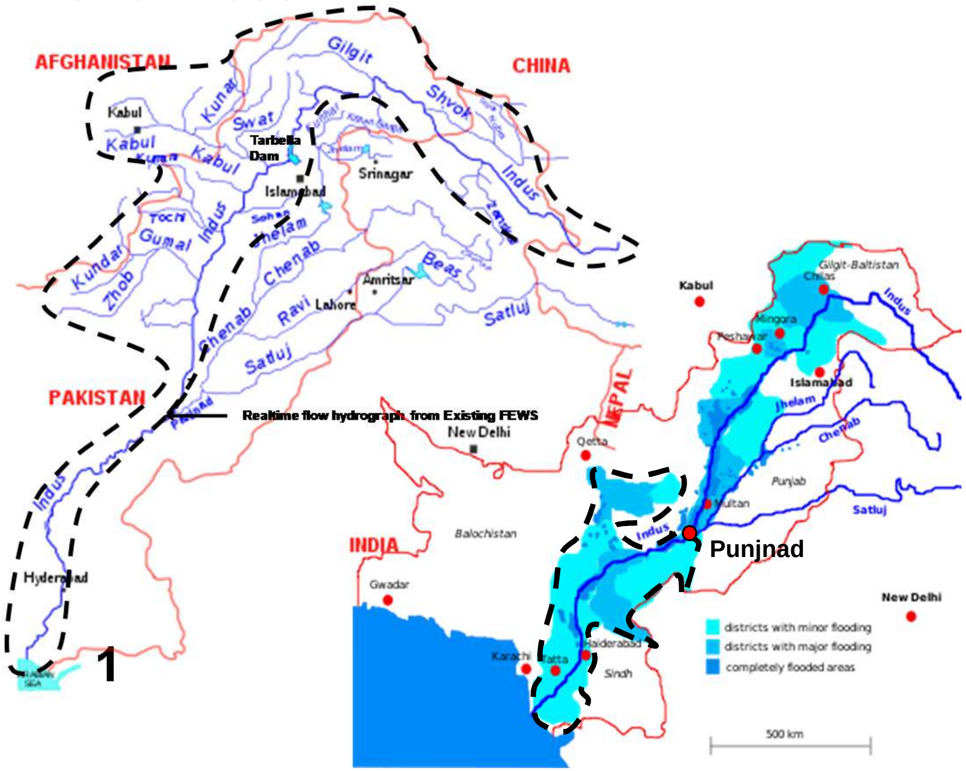
UNESCO Project (2 years: 2012-14)
Strategic Strengthening of Flood Warning and Management Capacity of Pakistan

United Nations
Educational, Scientific and
Cultural Organization

A. Strategic Augmenting of Flood Forecasting and Hazard Mapping Capacity

<u>**A-1 Development of Indus IFAS**</u>

A2- Floodplain and Hazard Mapping of Lower Indus



B. Knowledge Platforms for Sharing Transboundary Data and Community Flood Risk Information

B1. International Networking for Sharing of Transboundary Data

B2. Knowledge platform for timely national, provincial and district level data sharing

<u>***C. Capacity Development for Flood Forecasting and Hazard Mapping***</u>

- Master's Degree training at ICHARM for PMD, SUPARCO and FFC on flood forecasting/warning, hazard mapping and integrated flood management
- A short training course at ICHARM on IWRM and integrated flood management
- Training workshops in Pakistan conducted by UNESCO Islamabad

Example of Implementation Project for flood early warning system with satellite-based information

ADB-RETA 7276
in Indonesia to implement
IFAS-based flood forecasting
and warning system
for the Bengawan Solo River
(FY2009-2012)

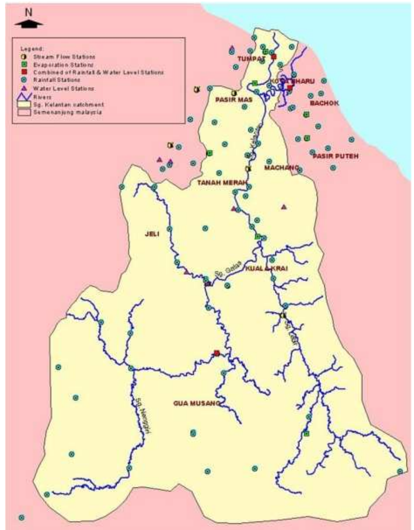
JST-JICA SATREPS Project on
Research and Development for
Reducing Geo-Hazard Damage in
Malaysia caused by Landslide &
Flood
(FY2011-2015)

Flood in Dec.2007

Training Workshop
with BBWS Solo in
March, 2010

Major target river basin for flood: Kelantan River

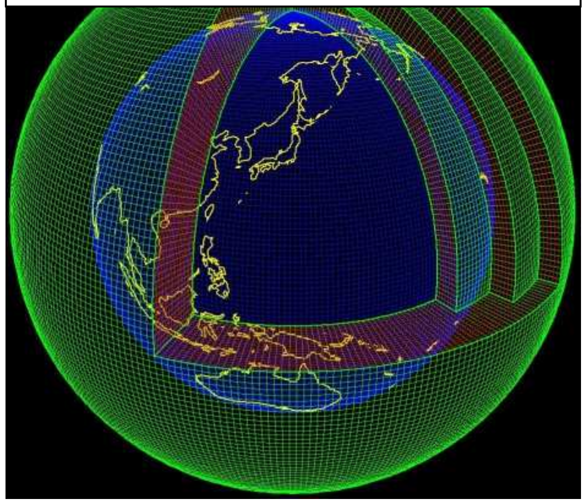
Wide-range analysis:
IFAS
High-res. analysis:
GETFLOWS

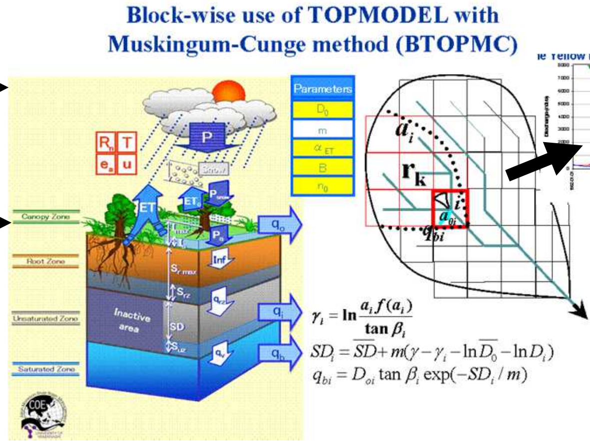


Assessment of the impact of climate change on flood disaster risk and its reduction measures over the globe and specific vulnerable areas

10–40km mesh
global stream paths

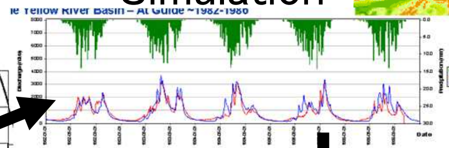
MRI-AGCM20km global meteorological simulation

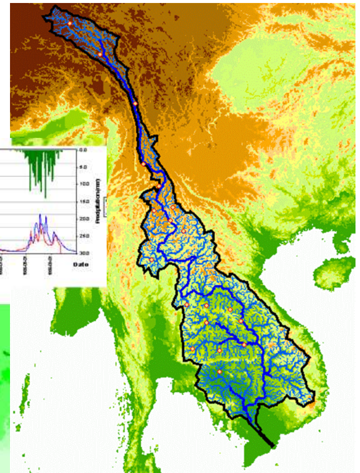


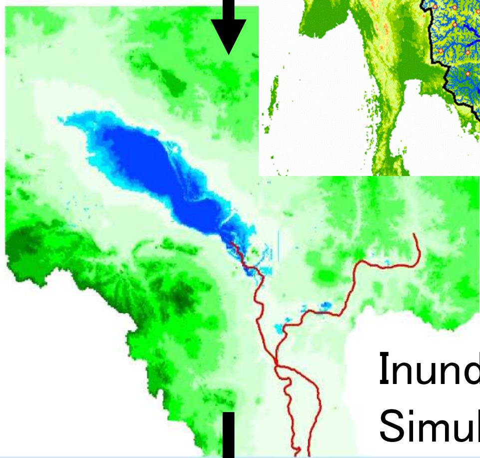


$$\gamma_i = \ln \frac{a_i f(a_i)}{\tan \beta_i}$$
$$SD_i = \overline{SD} + m(\gamma - \gamma_i - \ln \overline{D_0} - \ln D_i)$$
$$q_{bi} = D_{oi} \tan \beta_i \exp(-SD_i / m)$$

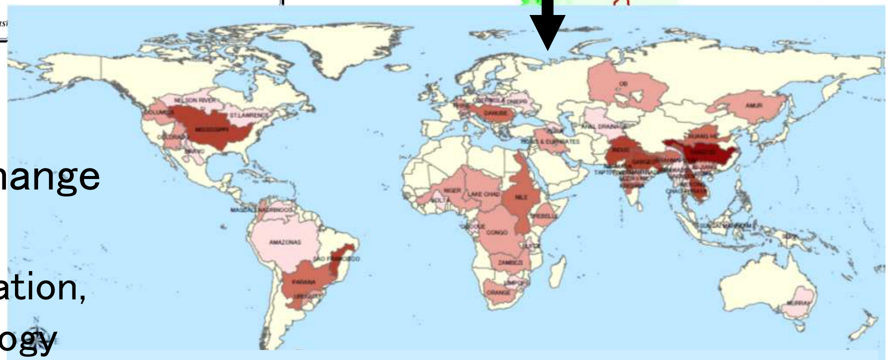
Hydrological Simulation







Inundation Simulation



Global Flood Risk Map

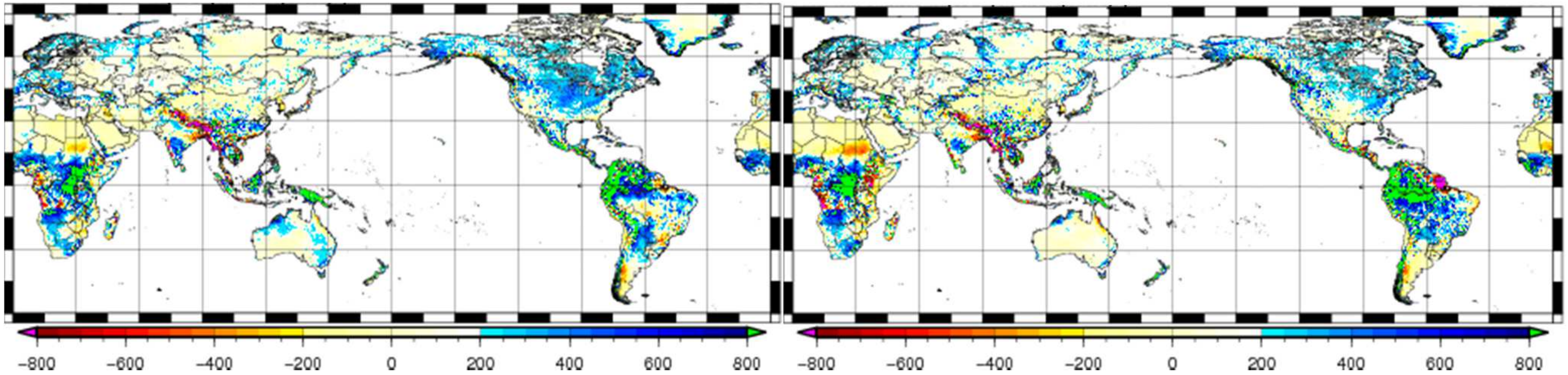
KAKUSHIN

Innovative Program of Climate Change Projection for the 21st Century
funded by Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT)

Project Period: 2007 Apr. – 2012 Mar.

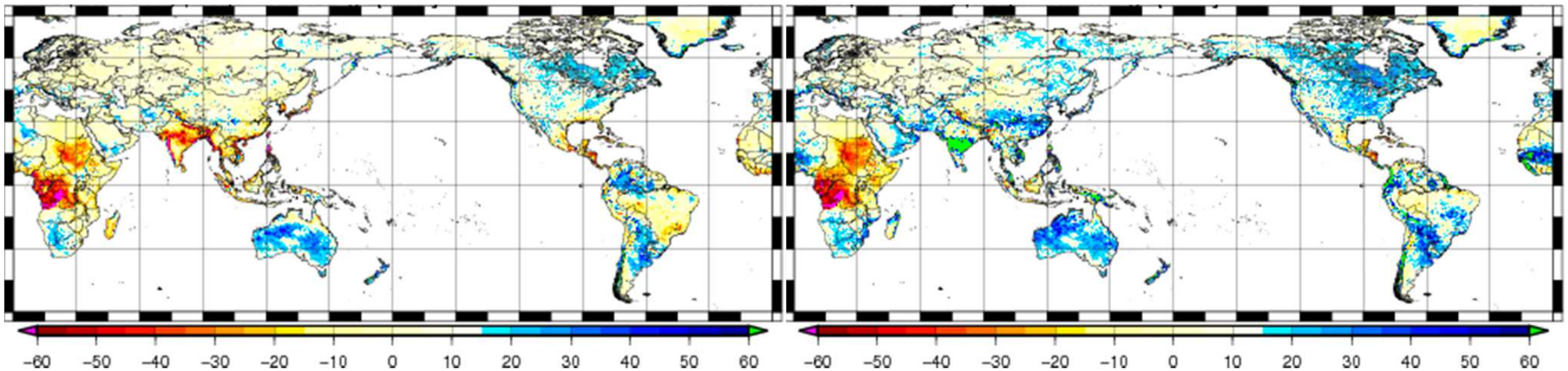
Bias in MRI-AGCMs' projections of rainfall

under present climate (1980-2004)



MRI-AGCM3.1S MRI-AGCM3.2S

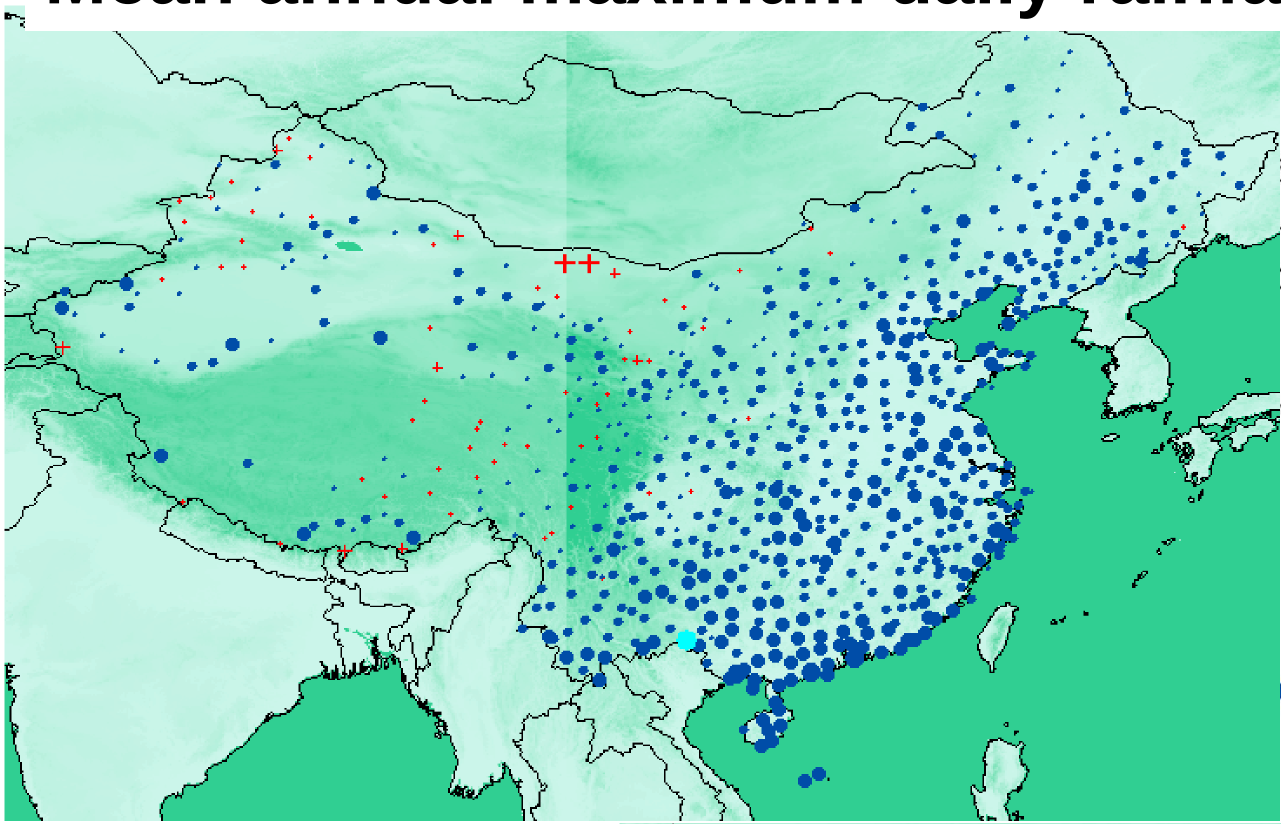
Bias (sim.- obs.) in mean **annual** rainfall

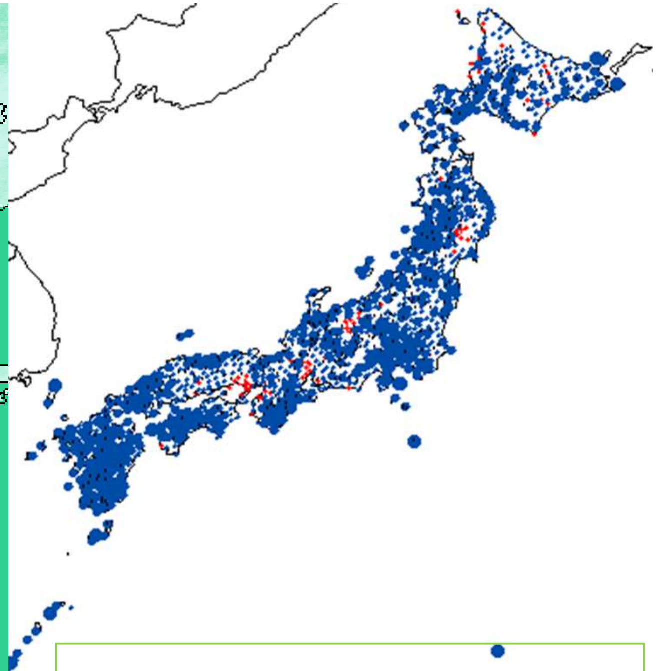


MRI-AGCM3.1S MRI-AGCM3.2S

Bias (sim.- obs.) in mean **top-0.5% daily** rainfall

Mean annual maximum daily rainfall Sim./Obs.(1980-20

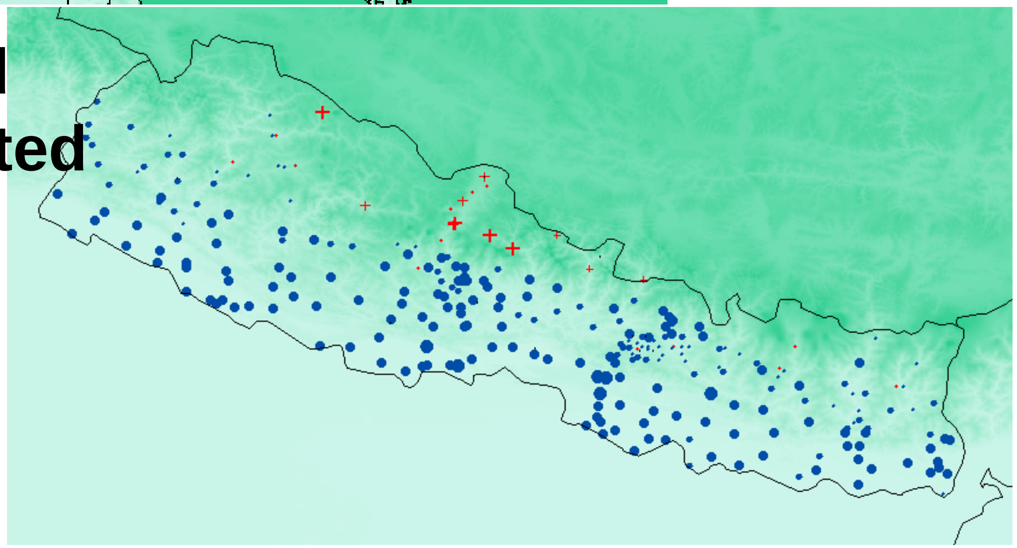




MRI-AGCM3.1S

Red：Overestimated

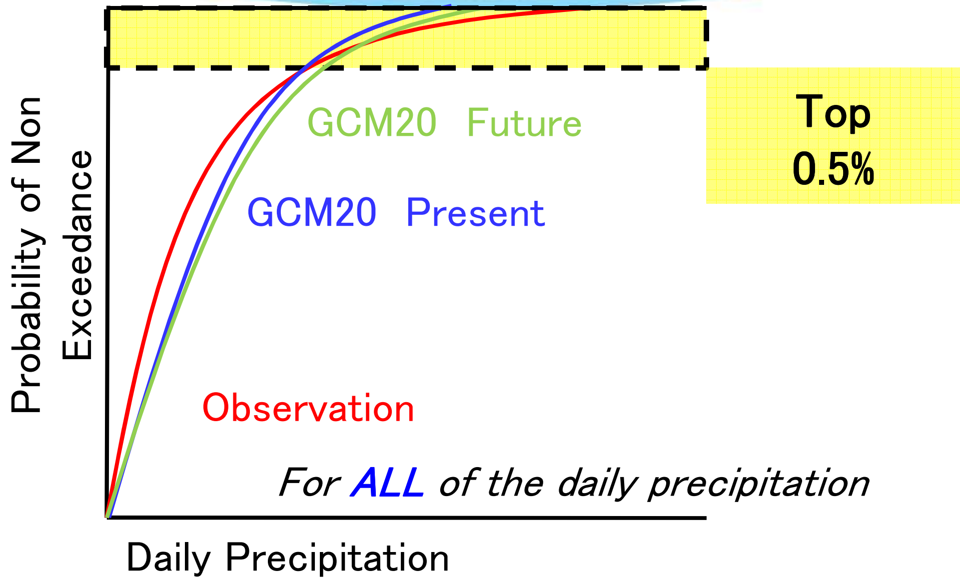
Blue：Under-estimated



Concept of bias correction method for MRI-AGCM

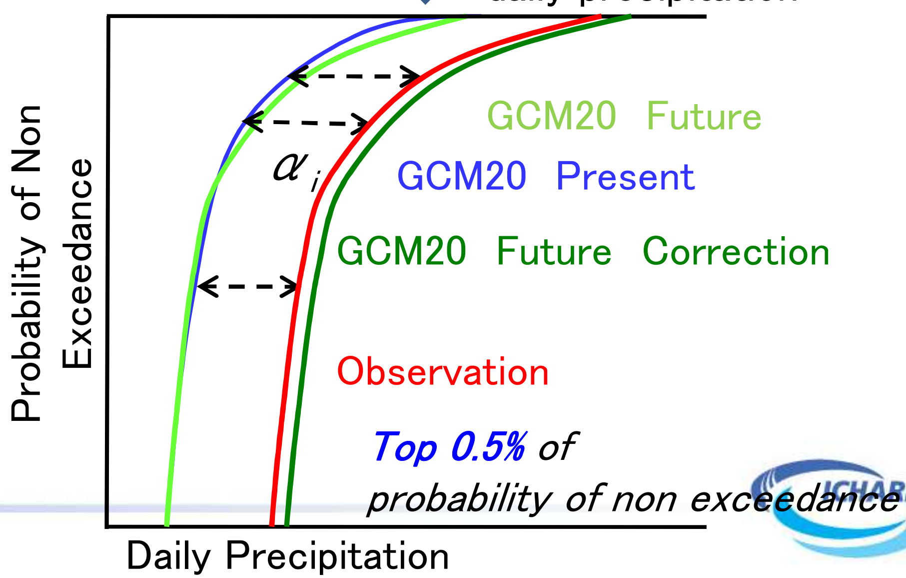
Hybrid Quantile Method (Inomata et al., 2011)

A) Extreme Value
⇒The samples in top 0.5% of prob. of non exceedance are considered.
B) Other value
⇒They are divided into each month.



①The samples in top 0.5% on probability of non exceedance for observation, GCM20 Present and GCM20 Future are subtracted.

Abstraction of top 0.5% daily precipitation



②The ratio for same rank. (α_i) between observation (P_Obs_i) and GCM20 Present ($GCM20\_Pre_i$) is estimated. α_i is regarded as a correction coefficient for each rank and multiplied to the value of GCM20 Future of same rank ($GCM20\_Fut_p$) and corrected value (P_Fut_p) is obtained.

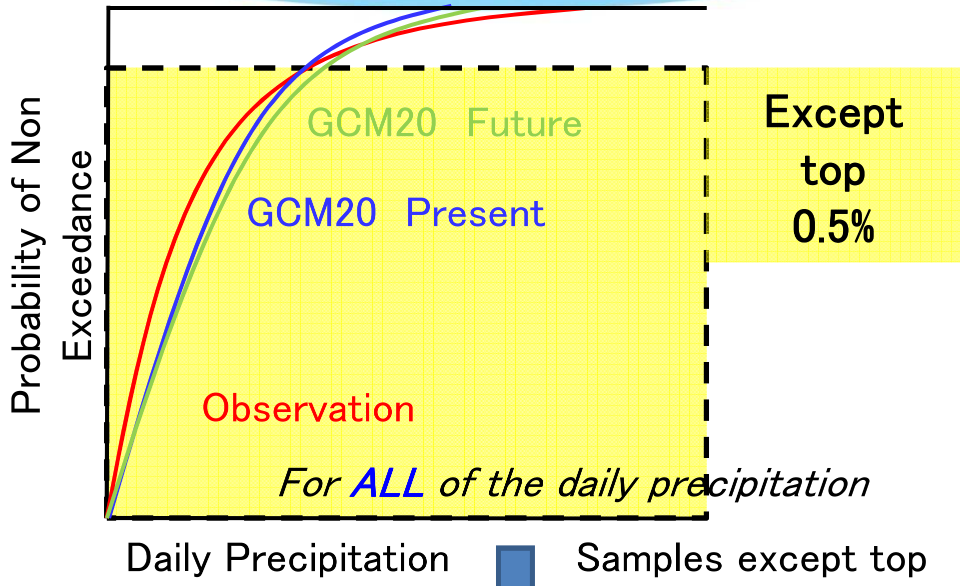
$$\alpha_i = \frac{P\_Obs_i}{GCM20\_Pre_i}$$

$$P\_Fut_i = \alpha_i \times GCM20\_Fut_i$$

Concept of bias correction method for MRI-AGCM(continue)

Hybrid Quantile Method (Inomata et al., 2011)

③Samples except top 0.5% on observation, GCM20 Present and Future are divided into each month.

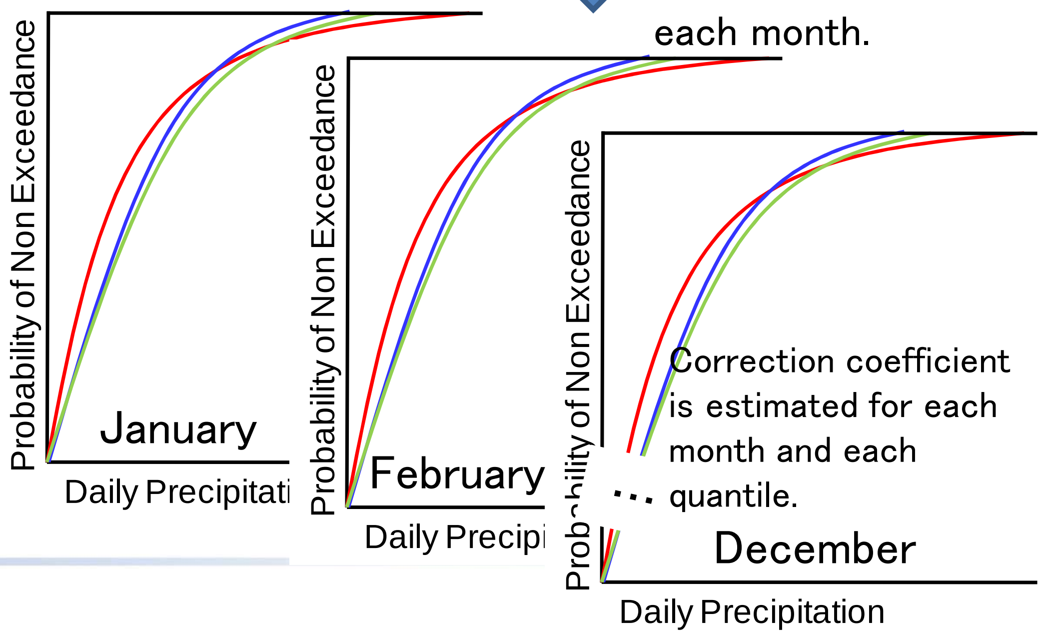


Samples except top 0.5% is divided into each month.

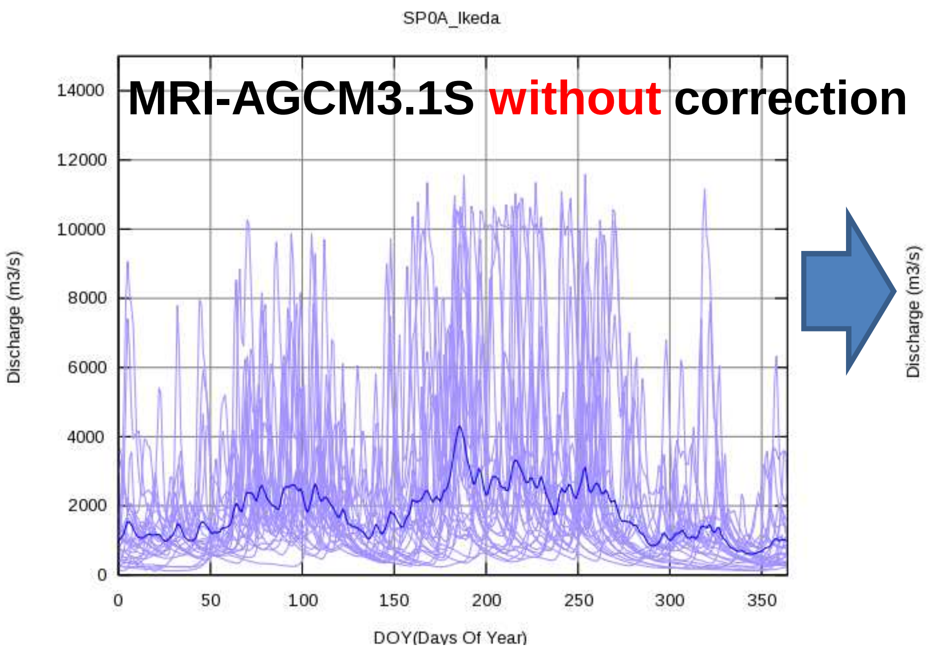
④The ratio between observation (*P_Obs*$_{m\_i}$) and GCM20 Present (*GCM20_Pre*$_{m\_i}$) is estimated for each month and each rank (α_{m_i}). α_{m_i} is regarded as correction coefficient and multiplied to GCM20 Future of same month and same rank (*GCM20_Fut*$_{m\_i}$) and corrected value (*P_Fut*$_{m\_i}$) is obtained.

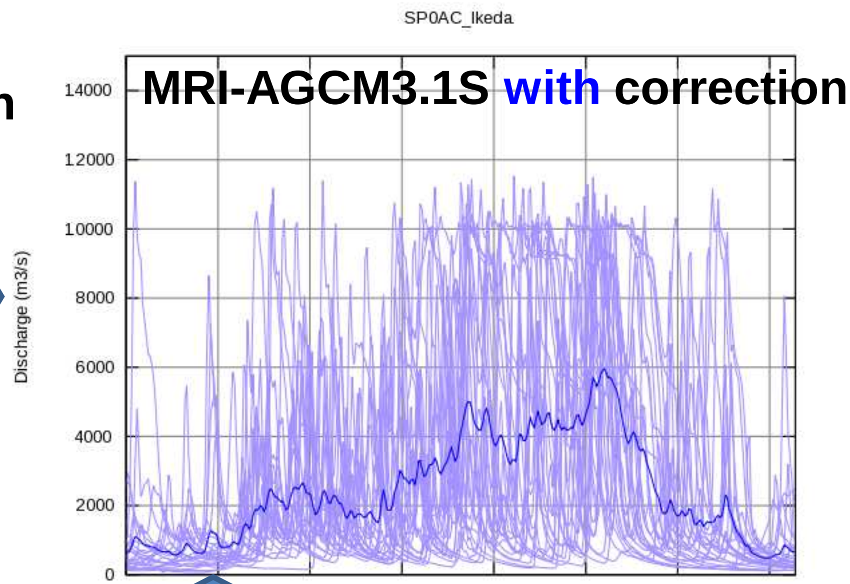
$$\alpha_{m\_i} = \frac{P\_Obs_{m\_i}}{GCM20\_Pre_{m\_i}}$$

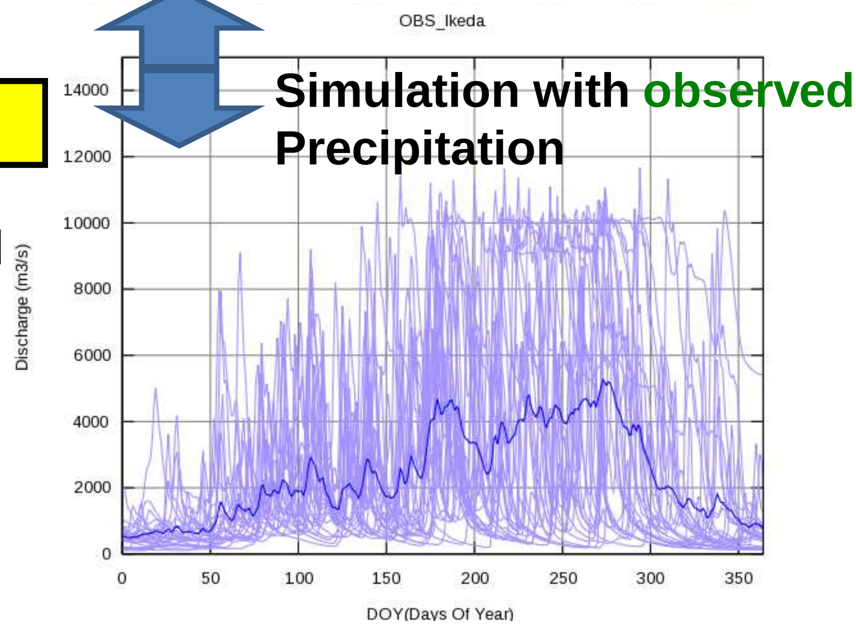
$$P\_Fut_{m\_i} = \alpha_{m\_i} \times GCM20\_Fut_{m\_i}$$



Effect of the bias correction method for river discharge simulation for the Ikeda station of the Yoshino River, Shikoku, Japan







Present climate condition（1980-2004)

■The runoff analysis **with** correction method shows lower discharge in winter and higher discharge in summer compared with the result **without** correction method.

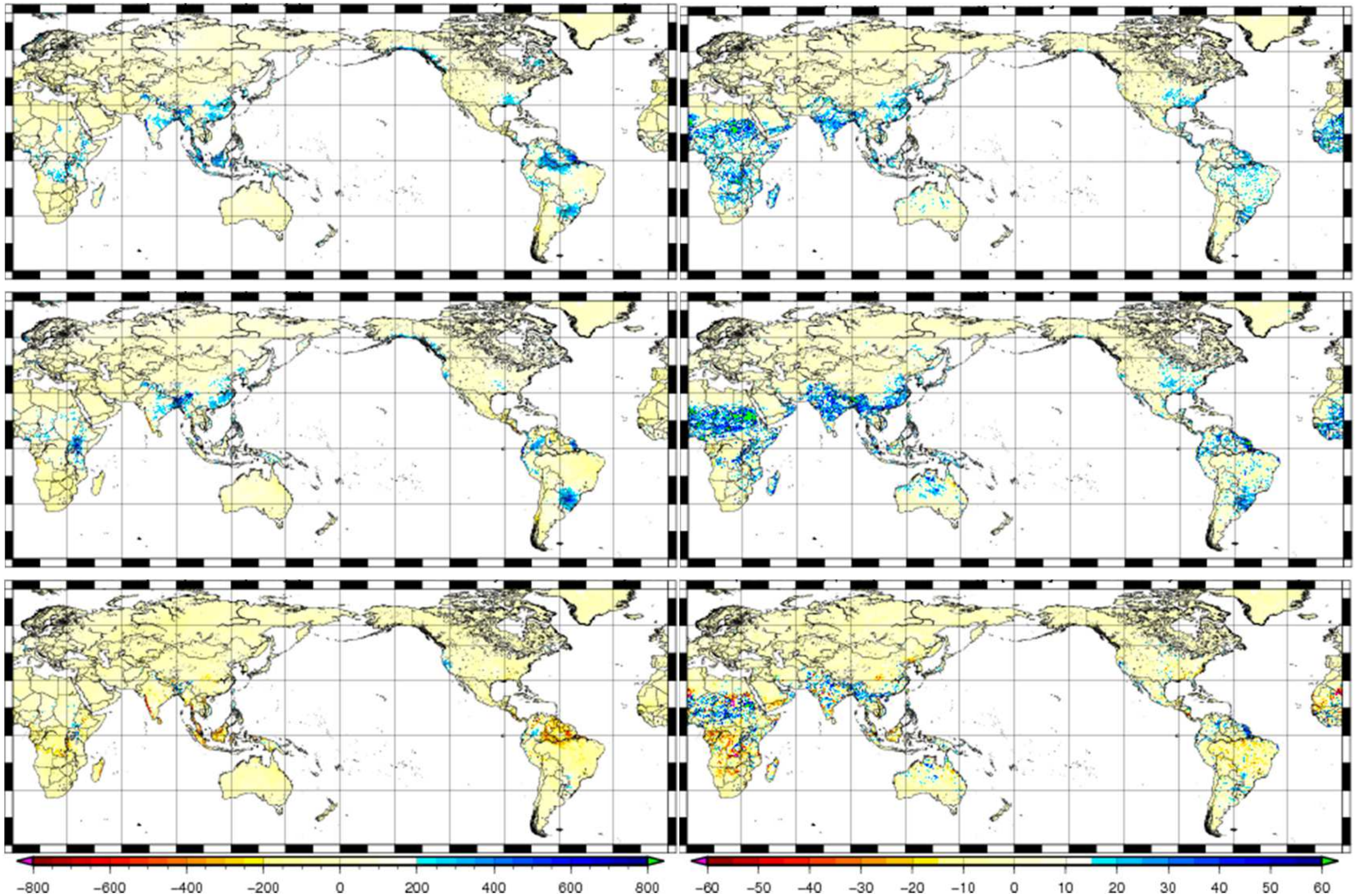
→ The runoff simulation with bias correction is just more coincident with the runoff analysis with **observed** precipitation.

Change of rainfall from Present to End-of-21c predicted by MRI-AGCMs (bias-corrected)

3.1S

3.2S

3.2S-3.1S
(Difference
of the above
two simulations)



Mean **annual** rainfall (bias-corrected)

Mean **top-0.5% daily** rainfall (bias-corrected)

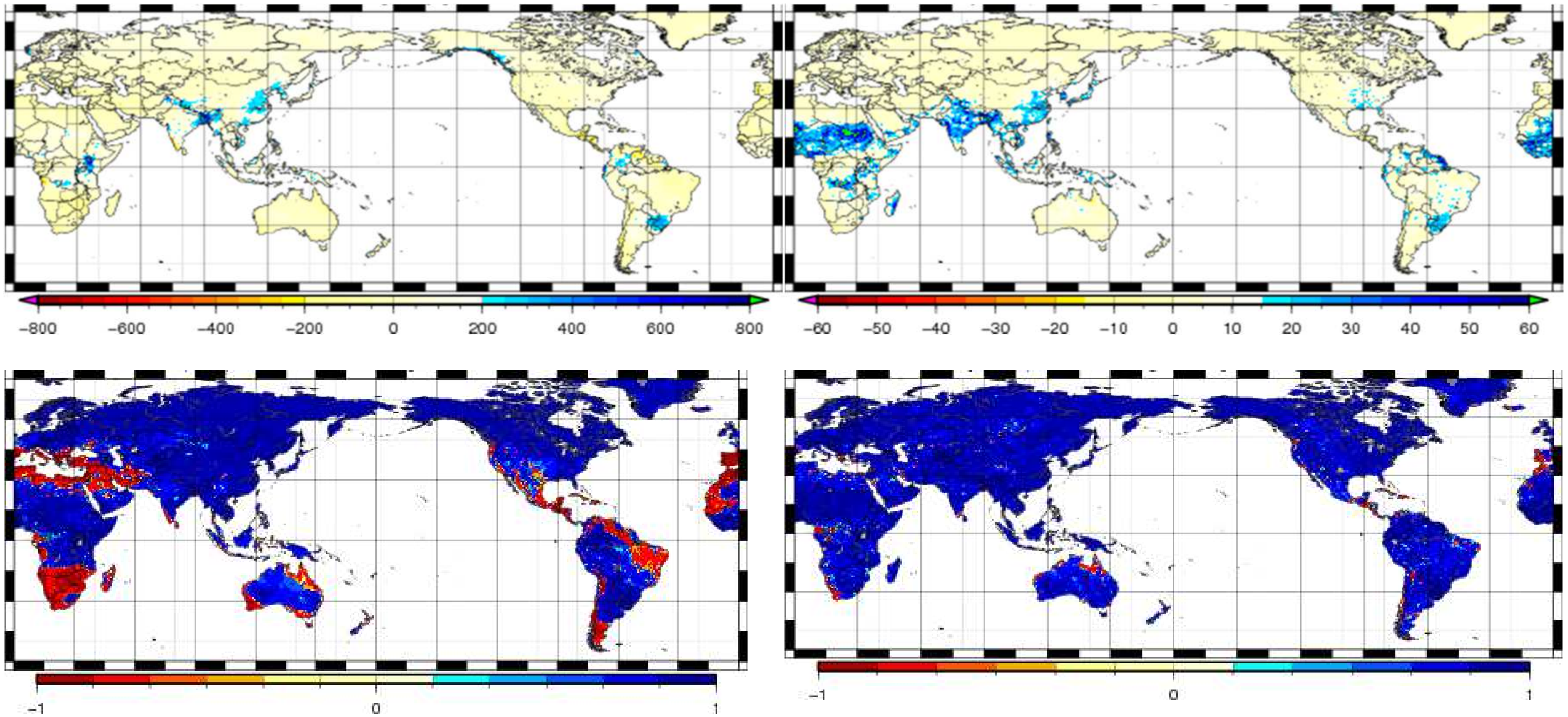
CHARM

Ensemble average of change of rainfall

from Present (1980-2004) to End-of-21c (2075-2099) with 6 different MRI-AGCM simulations

Ensemble average of 6 models

Coincidence of change trend among 6 models (increace or decrease)



mean **annual** rainfall — mean **top-0.5%** daily rainfall

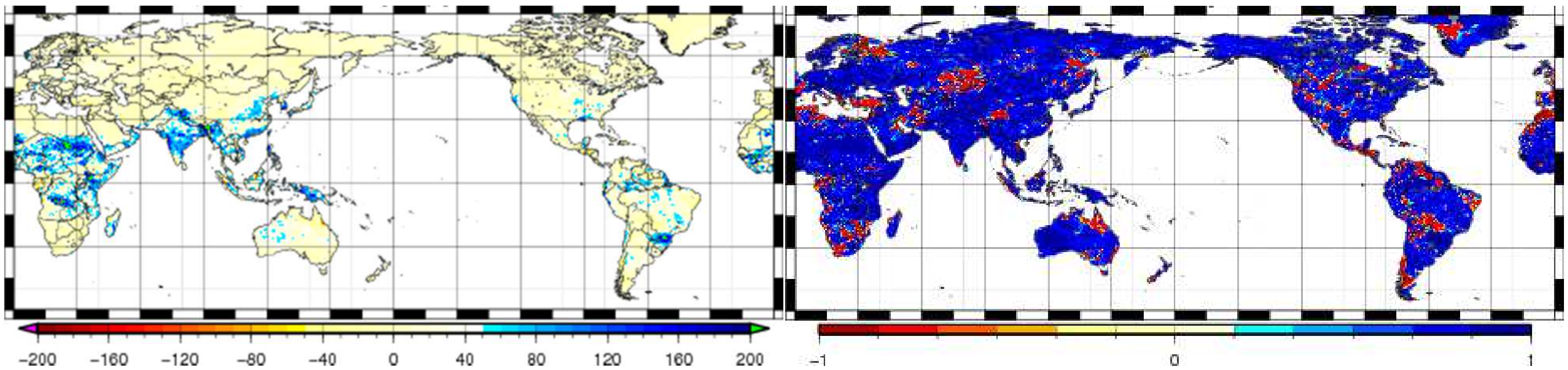
6 models = MRI-AGCM3.1S, MRI-AGCM3.2S (20km-grid), and
four MRI-AGCM3.2H (60km-grid) models
with different **4 scenarios on sea-surface temperature**

→ Absolute quantities of rainfall changes from Present to Future may be uncertain, but the trend (direction) of the change may be more certain.

Ensemble average of change of <u>standard deviation of annual rainfall</u>

(year-to-year variation of annual rainfall)

from Present (1980-2004) to End-of-21c (2075-2099) with 6 different MRI-AGCM simulations

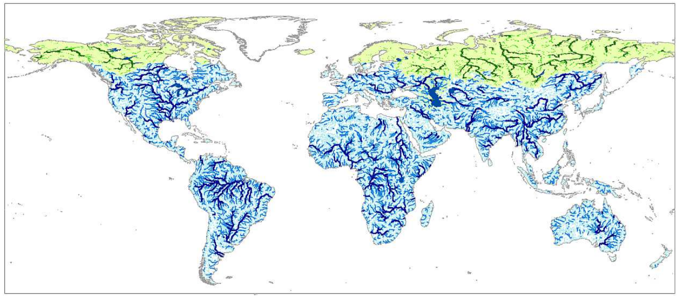


Ensemble average of 6 models

Coincidence of change trend among 6 models (increace or decrease)

→ Yearly variation of annual rainfall will increase in the future and, consequently, annual rainfall will be more unstable.

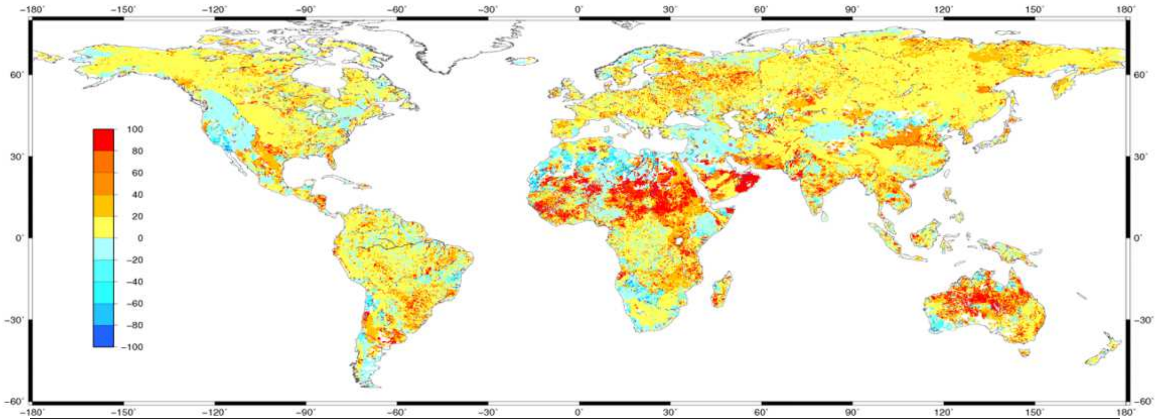
Projected change ratio of top-0.5% (extreme flood) daily river discharge



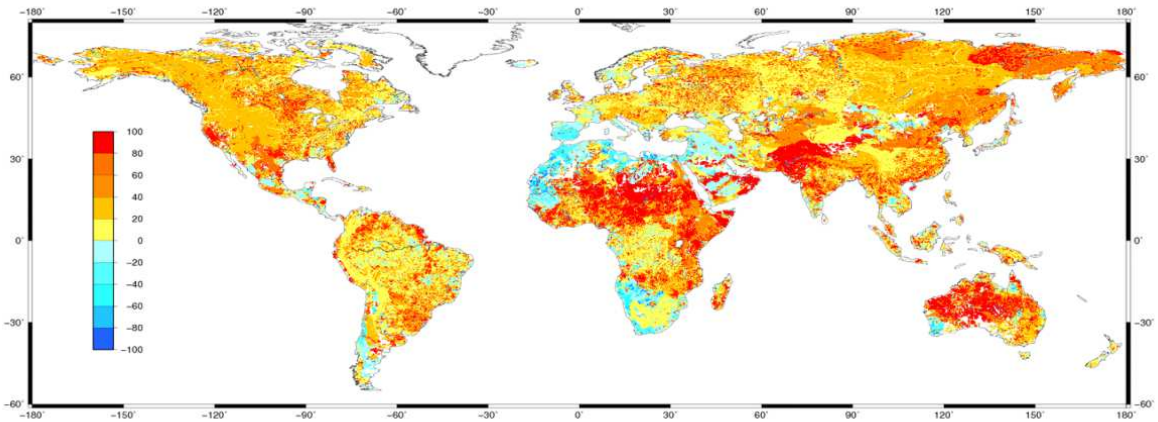
Global runoff model
(BTOP model with 20km-grid)
 +
MRI-AGCM3.2S
with the bias correction

Default model parameters were used here except a few rivers such as the Mekong.

Present: 1980-2004, **Near Future**: 2015-2039, **End of 21st Century**: 2075-2099



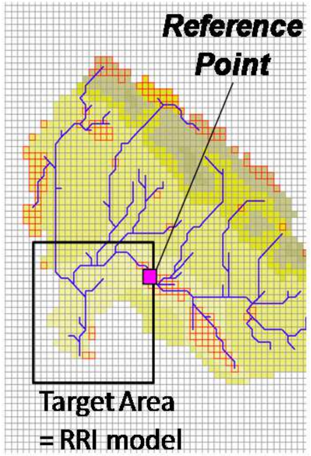
From Present to Near Future (3.2S with BC)



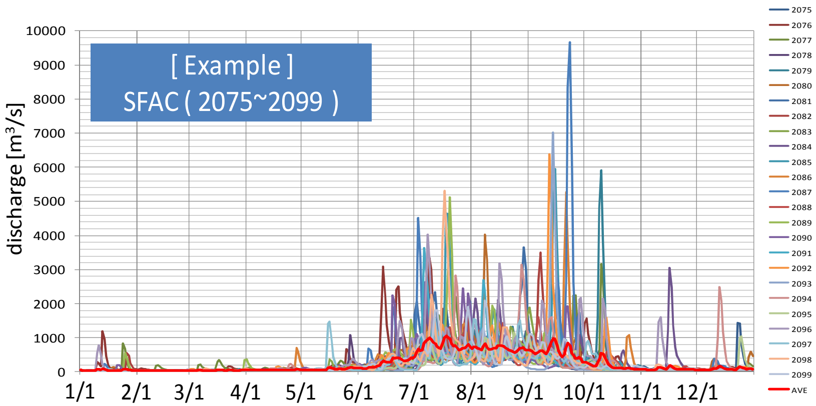
From present to End of 21st Century (3.2S with BC)

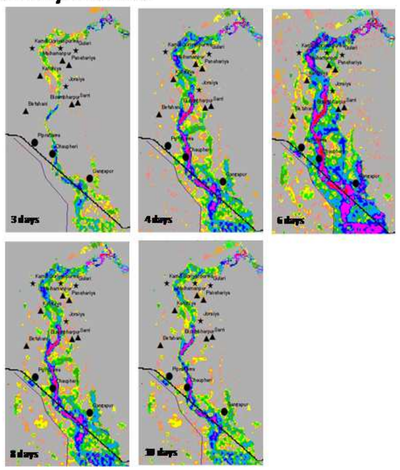
ICHARM-NDRI Workshop on Assessment of Flood and Inundations under the Effect of Climate Change in Lower West Rapti River Basin in Nepal

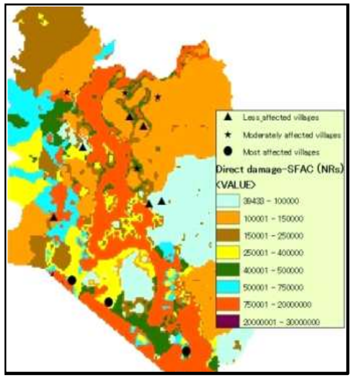
5 March, 2012
at The Himalayan Hotel, Kathmandu, Nepal

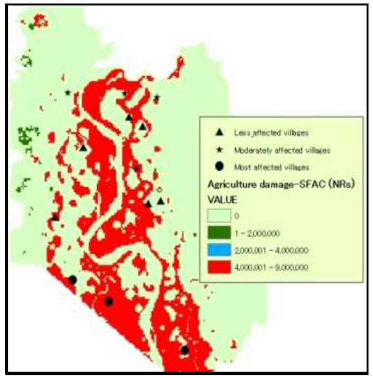


analysis area









1) households 2) rice

Projection of future damage as of 2

KAKUSHIN

(MEXT)

- ✓ MRI-AGCM3.1S&3.2S
- ✓ IFAS-PDHM(Ver.2)
- ✓ RRI (Rainfall-Runoff-Inundation Model

Flood measurement with ADCP aboard tethered boat with RTK-GPS

ADCP
on High speed river boat
with RTK-GPS

Commands of ADCP

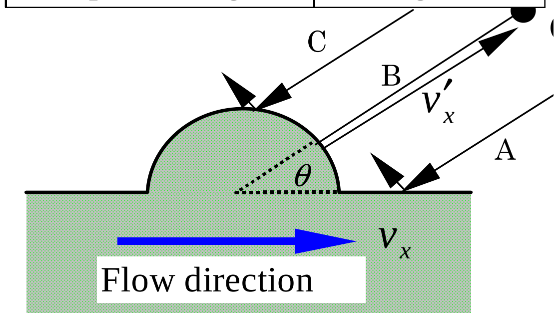
Bottom truck	BM5: 5
Pings for Bottom	BM3: 3
Pings for Water	WP3: 3
Type of band	WB0: Broad band
Distance for first blank	WS25: 25 cm
Mode of measurement	WM12: high speed mode
Number of layer	WN40: 40
Thickness of layer	WS25: 25 cm

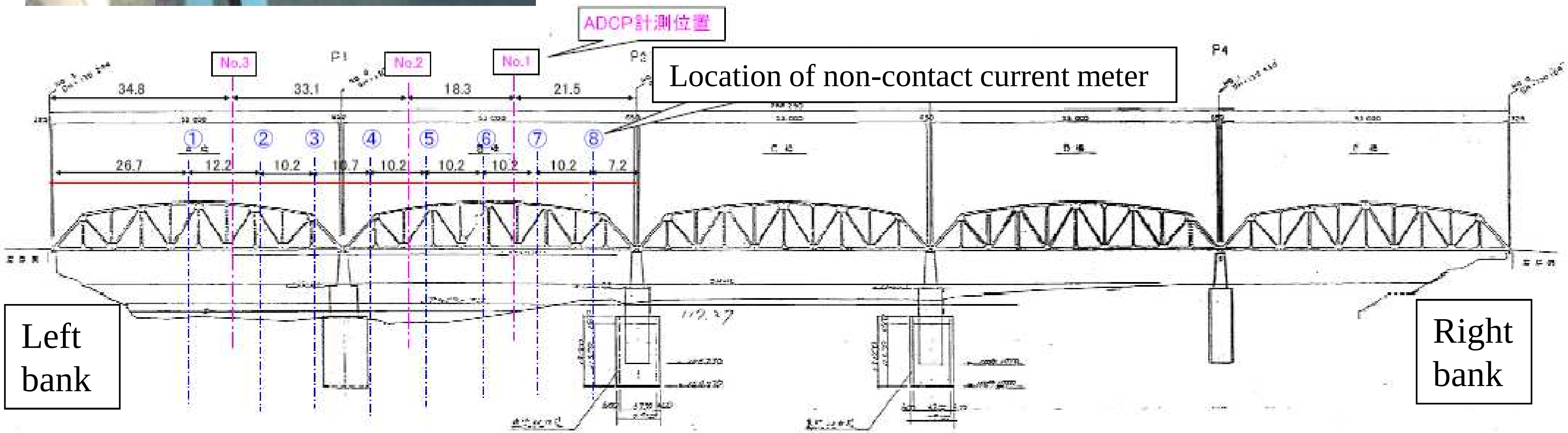
Non-contact current meter system to enable automatic safe measurement of severe flood flow in Asian monsoon region

Radio current meter (doppler type)

Specification (non-fixed type)

Frequency	24.15 gHz
antenna type	horn antenna
half power angle	12 degree





Capacity Development Programs

- **Short training courses**
  - Flood hazard mapping (FHM) course (2004-2008, JICA)
  - Local emergency operation plan with FHM (2009-, JICA)
  - River and Dam engineering course (1973-, JICA)
  - Comprehensive Tsunami training (2008, UNISDR)
- **Aftercare program** for implementation at trainees local communities (2006-, JICA)
  - KL, 2007; Guangzhou, 2008; Manila, 2009; Hanoi, 2010
- **Master Course on Water-related Disaster Management** with National Graduate Institute for Policy Studies (GRIPS) supported by JICA since October 2007
  - 10 students from Bangl., China, India, Nepal, Japan (2008)
  - 8 students from Bangladesh, China, Indns, Nepal, Ethiopia, Thai. (2009)
  - 12 students (2010), 15(+4) students (2011)
- **PhD Course** with GRIPS 1 student (2010), 3 students (2011 & 2012)


Thank you for your attention!
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ICHARM / PWRI