Global Flood Alert System (GFAS) – Streamflow

Integrated Flood Analysis System (IFAS)

for

prompt implementation of flood analysis & forecasting system in poorly-gauged rivers using multiple sources of rainfall and global GIS databases

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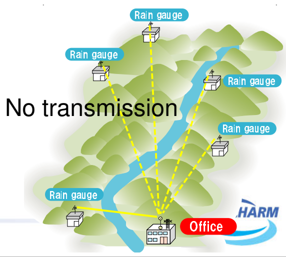
Problems of flood forecasting system installation in poorly-gauged river basins

- Difficulty to get real-time hydrological data in the upstream of a transboundary river basin
- Insufficient of implementation and maintenance of ground-based real-time hydrological observation stations, such as raingauge and river discharge gauging station with data transmission system.
- Lack of the data required for creation of a flood forecasting model such as altitude, land use, river channel network, etc.
- Difficulty of the expense burden which is needed for a flood forecasting system installation
- Insufficient framework to enhance technical capabilities

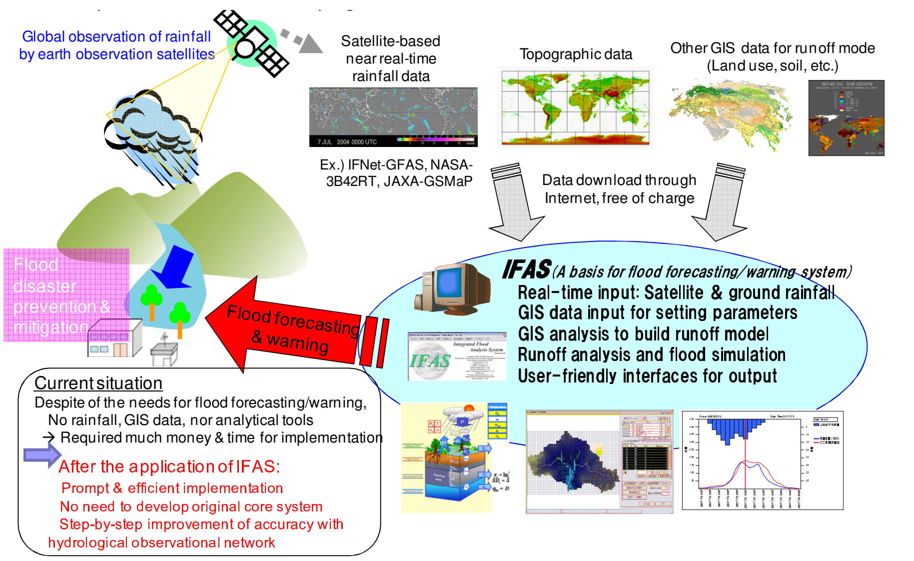
Rainfall observation by hand

Houses built along a river



Integrated Flood Analysis System IFAS

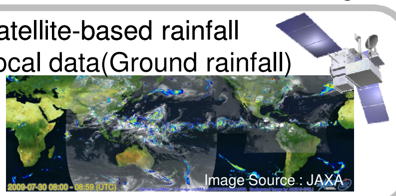
Toolkit to implement "Global Flood Alert System (GFAS) – Streamflow"



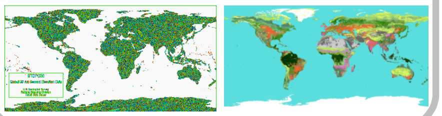
Concept of development IFAS
&
Introduction of satellite-based rainfall data

GFAS-Streamflow = Prompt implementation of flood forecasting system in poorly-gauged river basins all over the world with satellite-based rainfall data and global GIS data

Satellite-based rainfall
Local data(Ground rainfall)

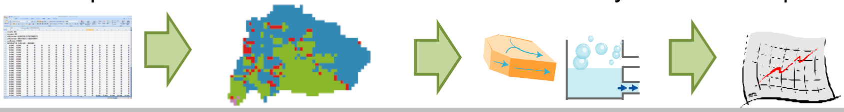


Global GIS data
Elevation data, Land use data, etc.



IFAS

Data input → Model creation → Run-off analysis → Output



(Possible to set dam outflow)

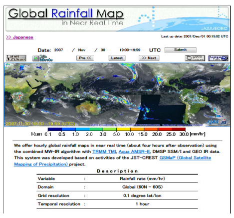
(Exportable to Google Earth)

Prompt & effective implementation of flood forecasting system and step-by-step improvement of the accuracy with in-situ data

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.

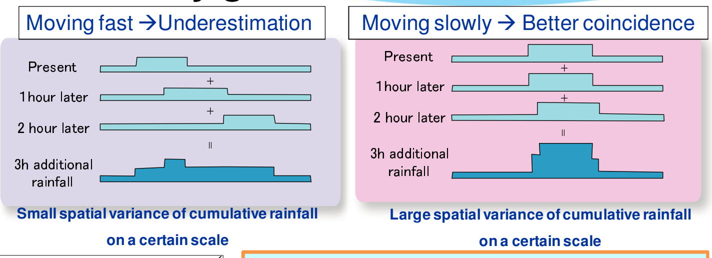
Product name	3B42RT	CMORPH	GSMaP_NRT
Developer and provider	NASA/GSFC	NOAA/CPC	JAXA/EORC
Coverage	N60° - S60°		
Resolution	0.25°	0.25°	0.1°
Resolution time	3 hours	3 hours	1 hour
Time lag	10 hours	15 hours	4 hours
Coordinate system	WGS		
Historical data	Dec 1997-	Dec 2002-	Dec. 2007～
Sensors	TRMM/TMI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

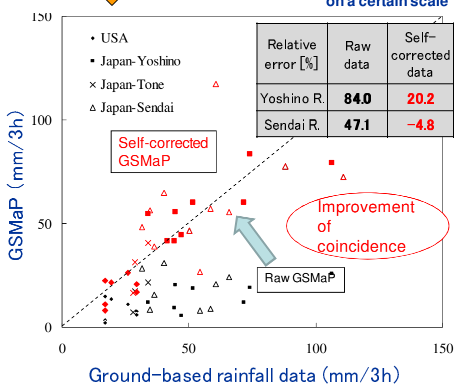


GSMaP_nRT

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

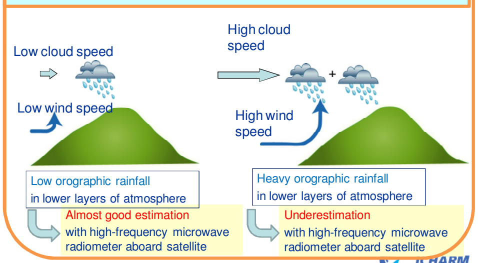
Algorithm for self-correction of satellite-based rainfall data without any ground-based rainfall data





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.



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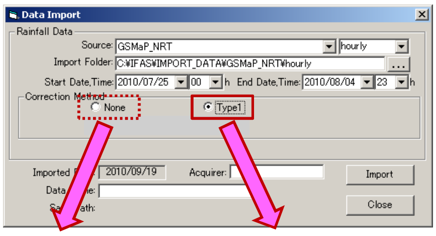
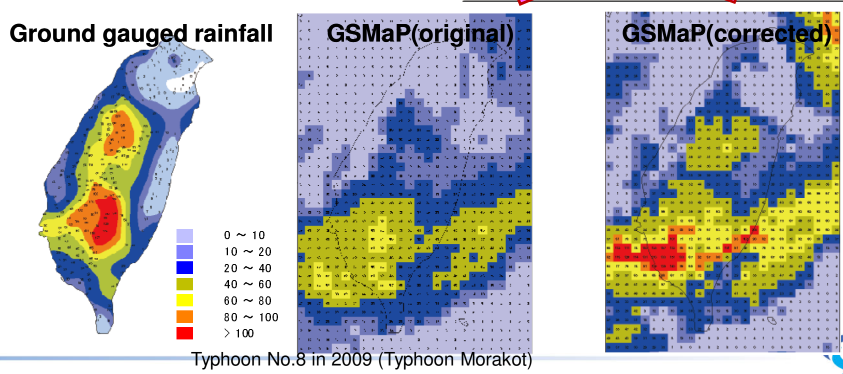
Effect of the ICHARM's self-correction method of satellite-based rainfall

- Self-corrected GSMaP_nRT can effectively reduce the degree of underestimation for heavy rainfall data **without any real-time ground-based rainfall data.**
- **IFAS implements this self-correction method.**





Typhoon No.8 in 2009 (Typhoon Morakot)
Rainfall distribution in Taiwan (3-hour cumulative rainfall)

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Main features

Not only ground-based but also <u>satellite-based</u> rainfall data as an input data

Model creation using <u>global GIS data</u>

Development of IFAS 1st Phase (FY2005-2007)

Under the framework of “joint research & develoment” among

ICHARM / Public Works Research Institute (PWRI),

Infrastructure Development Institute (IDI / Secretariat of IF-Net),

and nine major civil-engineering consulting companies, as shown below:

International Centre for Water Hazard and Risk Managemennt (ICHARM)
Public Works Reserch Institute (PWRI)
CTI Engineering Co., Ltd.
NIPPON KOEI Co., Ltd.
IDEA Consultants, Inc.
Yachiyo Engineering Co., Ltd.
Pacific Consultants Co., Ltd.
Tokyo Kensetsu Consultants Co., Ltd.
NEWJEC Inc.
CTI Engineering International Co., Ltd.
Infrastructure Development Institute (IDI)
Kokusai Kogyo Co., Ltd.

Design concept of IFAS

1. To prepare interfaces to get satellite-based rainfall data in addition to ground-based rainfall data, to secure the worldwide availability of input data for flood forecasting/analysis system.

2. To adopt two types of distributed-parameter hydrologic models, the parameters of which can be estimated as the first approximation based on globally-available GIS databases to secure the worldwide availability of hydrologic models for flood forecasting/analysis.

3. To implement GIS analysis modules in the system to set up the parameters for the flood forecasting/analysis model, therefore no need to depend on external GIS softwares.

5. To prepare a series of easy-to-understand graphical user interfaces for data input, modeling, runoff-analysis, and displaying the outputs.

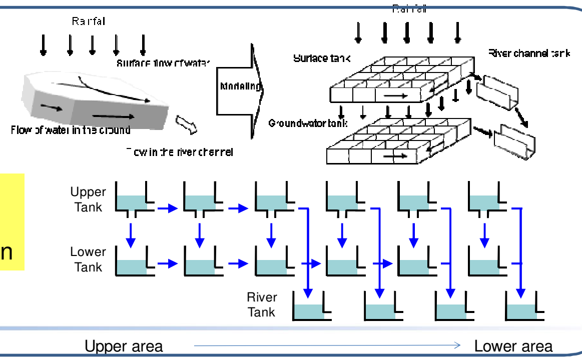
6. To distribute the executable program, free of charge, from the ICHARM/PWRI website

Default runoff analysis models on IFAS

- Three types of distributed hydrological models
  - PWRI Distributed Hydrological Model (PDHM Ver.2) (for flood events, below)
    - Suzuki, Terakawa & Matsuura (1996), Inomata & Fukami (2007), IFAS Ver.1.2 Manual (2009)
  - PWRI Distributed Hydrological Model (PDHM Ver.1) (for flood & long-term flows)
    - 3-layer model for wide availability from low to high flows
    - Yoshino, Yoshitani & Horiuchi (1990) → to be released in IFAS Ver.1.3
  - BTOP Model (for a variety of hydrological conditions)
    - Takeuchi, Hapuarachchi, Zhou, Ishidaira & Magome (2008) → under preparation

PDHM Ver.2

2-layer model for quick flood runoff simulation

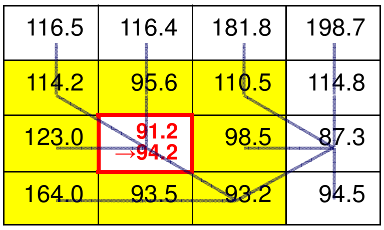


Flood runoff simulation model creation using global GIS data

Import data

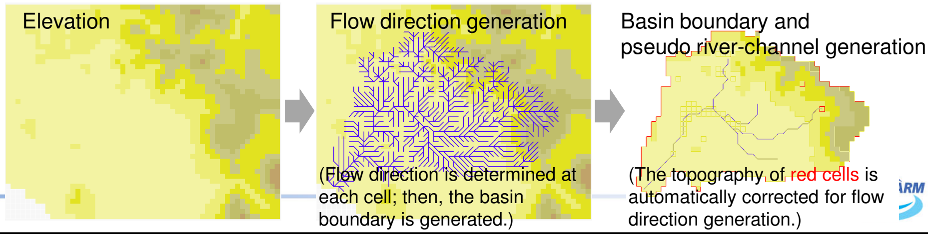
Type	Product	Provider
Elevation	Global Map(Elevation data)	ISCGM
	GTOPO30	USGS
	Hydro1k	USGS
Land use	GLCC	USGS
	Global Map(Land cover)	ISCGM
	Global Map(Land use)	ISCGM
Geology	Geology	CGWM
Soil type	Soil Texture	UNEP
	Soil Water Holding Capacity	UNEP
	Soil Depth	GES

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



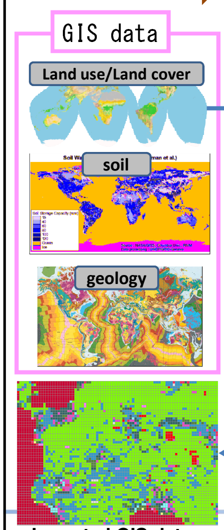
Modify elevation until all sells are decided their flow directions

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

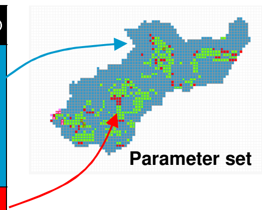


Parameter estimation using GIS data [surface / groundwater

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



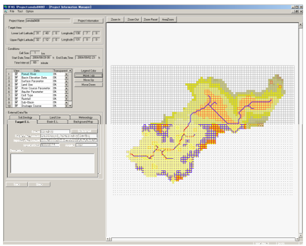
Land use classification (GlobalMap)	Surface parameter	Infiltration capacity	Rough -ness	○○
Broadleaf Evergreen Forest	1	0.0005	0.7	…
Broadleaf Deciduous Forest				
Needleleaf Evergreen Forest				
Needleleaf Deciduous Forest				
Mixed Forest				
Tree Open				
Shrub	2	0.00002	2	…
Herbaceous				
Herbaceous 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				



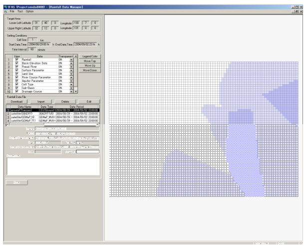
◆IFAS has already set default parameter.
◆Each parameter reflects local condition.

Interface display

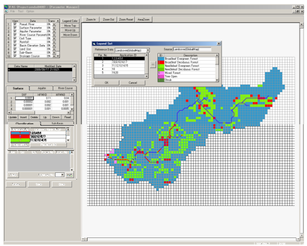
Main display



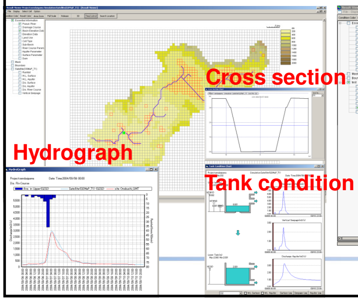
Edit display of rainfall data



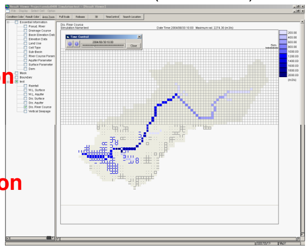
Setting display of parameter



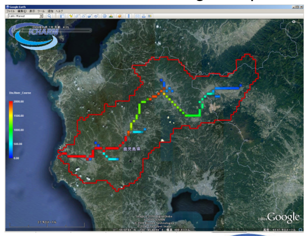
Calculation result



Calculation (Plane view)

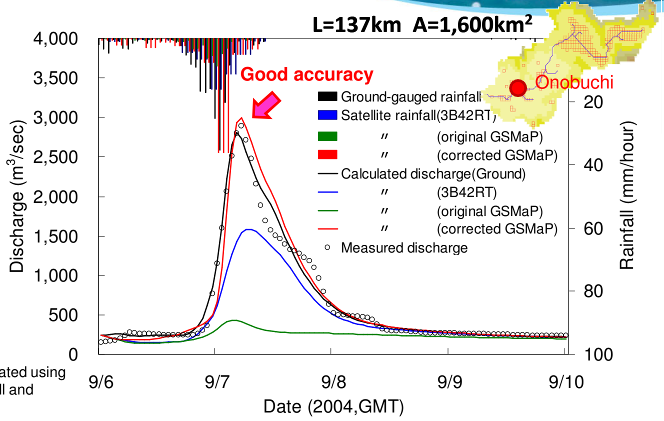


Plane view on Google Map



Examples of IFAS applications to flood runoff analyses

IFAS-based runoff analysis: Sendai River, Japan



Parameters are calibrated using ground-gauged rainfall and measured discharge

•A flood-runoff event analysis in the Sendai River basin of Japan was very accurately reproduced with IFAS using the ICHARM's self-corrected satellite-based rainfall data without any in-situ ground-based rainfall data, in spite of the under-estimation of rainfall rate in its original GSMaP product.

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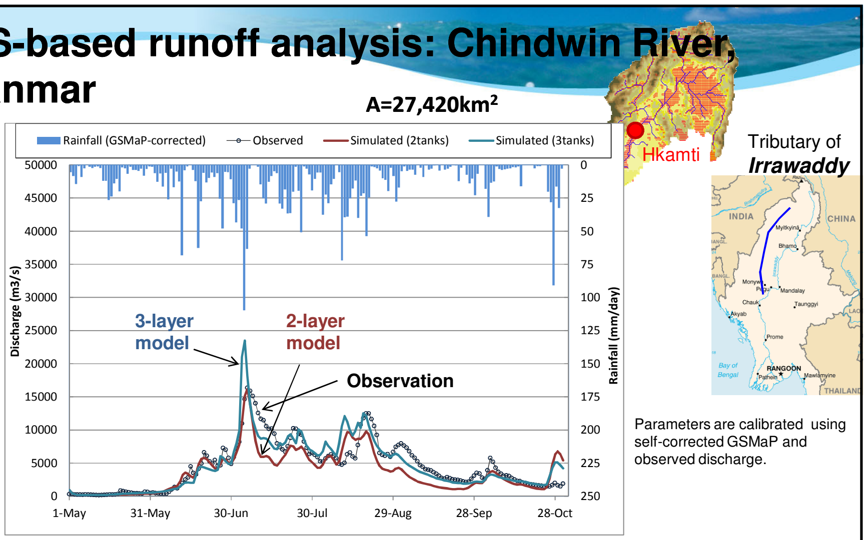
IFAS-based runoff analysis: Chindwin River, Myanmar



•The 2-tank model (PDHM Ver.2) reproduced the 1st major flood peak level and the other major flood peak timings well, but low flows were much underestimated.
•The 3-tank model (PDHM Ver.1) reproduced both major flood peaks (timing and level) and their recessions better. The 1st major flood peak level seems overestimated, but this may show the possibility of inundation in the upstream of the gauging station.

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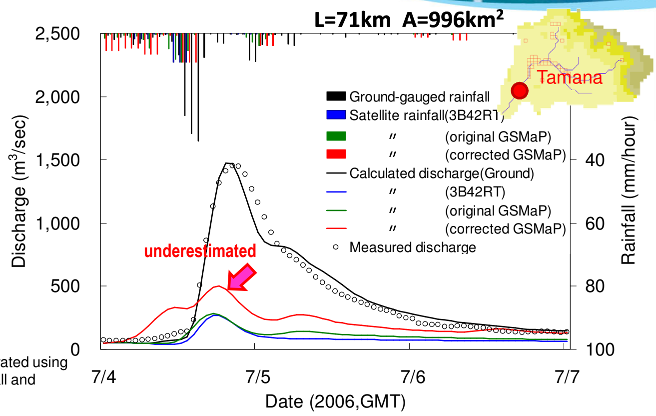
IFAS-based runoff analysis: Kikuchi River, Japan

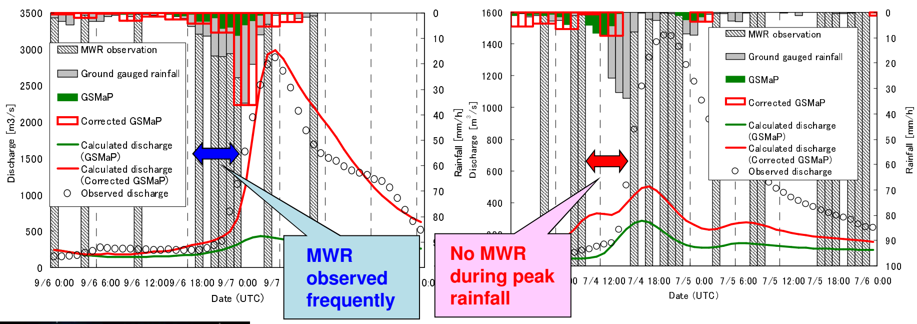


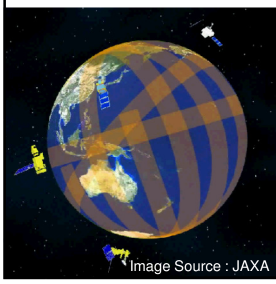
Parameters are calibrated using ground-gauged rainfall and measured discharge

Why was the self-correction of GSMaP unsuccessful for this case?

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

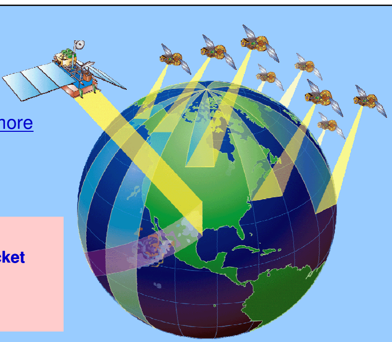
Core Satellite

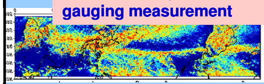
Dual Frequency Radar
Multi Frequency Radiometer

✧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



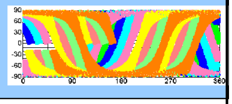


8 Constellation Satellites

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

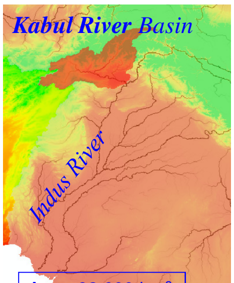
Flood in Pakistan, 2010

- Heavy rain from late July due to monsoon which brought inundation wide-area in the Indus river and affected about 20 million people.
- In the KP province, "flash flood" brought most of the number of deaths in this flood event.
- In Peshawar, it rained 274mm/day (over 2 times as the highest record before)
- GSMaP underestimated. → The ICHARM's self-correction-based or Thiessen-polygon-based corrections were conducted.

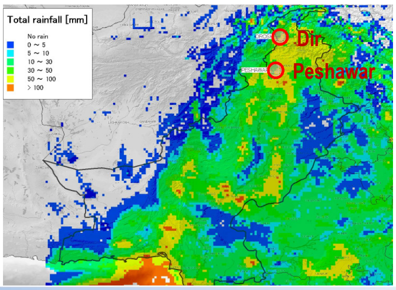
Province	Deaths	Injured	Houses Damaged	Villages Affected	Population Affected
BALOCHISTAN	48	102	75,261	2,604	*672,171
Khyber Pakhtunkhwa	1,154	1,193	200,799	2,834	4,365,909
PUNJAB	110	350	500,000	3,132	8,200,000
SINDH	186	909	1,058,862	7,277	6,988,491
AJ&K	71	87	7,108	No info	245,000
Gilgit Baltistan	183	60	2,830	No info	81,605
FATA	86	84	4,614	Awaited	Awaited
Total	**1,838**	**2,785**	**1,849,474**	**15,847**	**20,553,176**

** Additional 600,000 IDPs from Sindh are living in Balochistan*

Table updated from NDMA, 06 September 2010

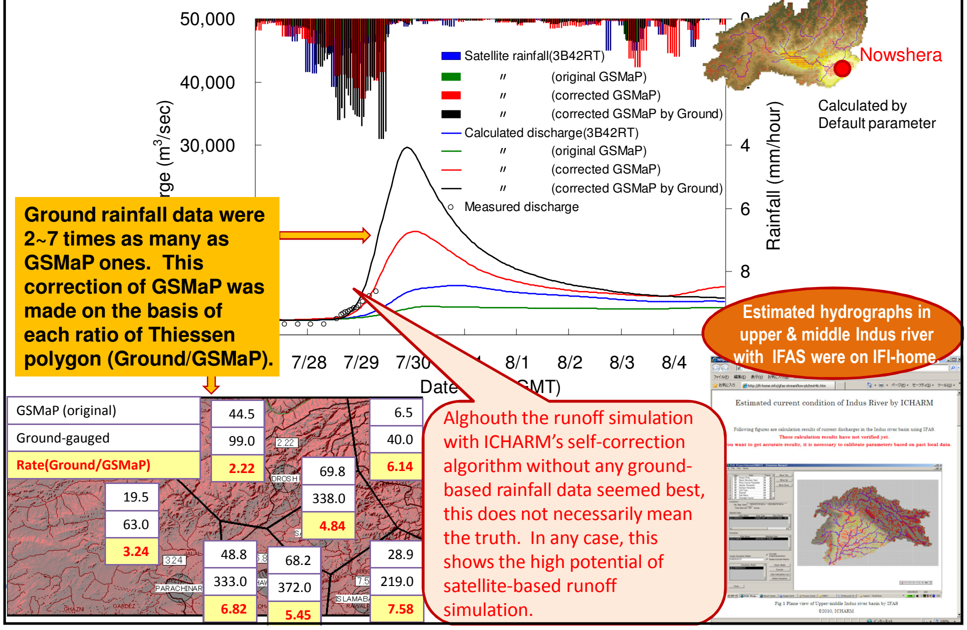


Area: 92,600 km²
Length: 700 km



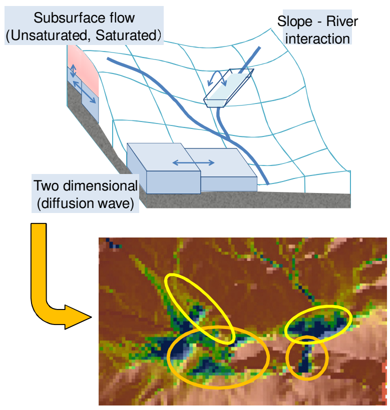
GSMaP_NRT(total amount: 7/27~31)

IFAS-based runoff analysis: Kabul River, Pakistan

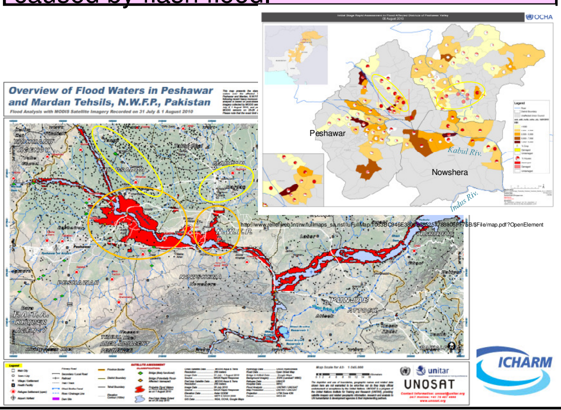


Comparison between satellite-based inundation extent and inundation simulations with another ICHARM's Rainfall-Runoff-Inundation (RRI) Model for Pakistan flood, August 2010

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



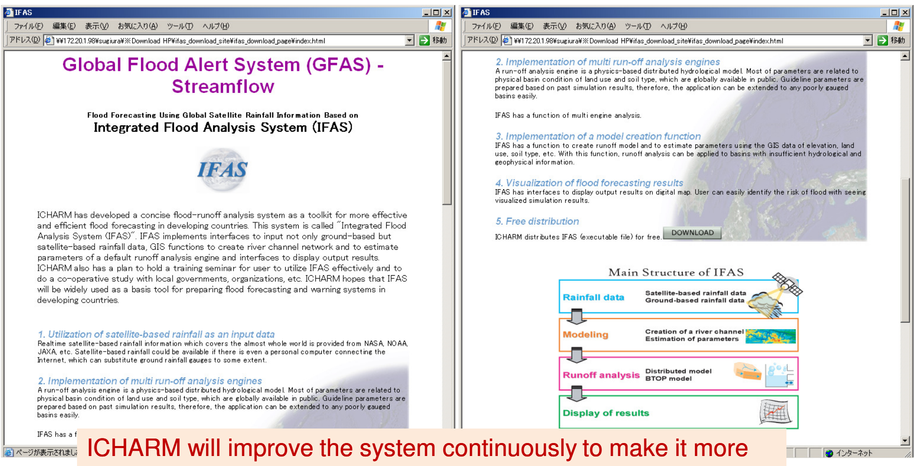
Sayama et al. (2010)



Dissemination activities

ICHARM Website to download IFAS (only IFAS-PDHM Ver.1.2 as of 2011/4)

http://www.icharm.pwri.go.jp/index.html



ICHARM will improve the system continuously to make it more user-friendly software and contribute to flood mitigation at local communities. (Ver.1.3 will be coming soon!)

Training workshops (2008 – 2011/3)

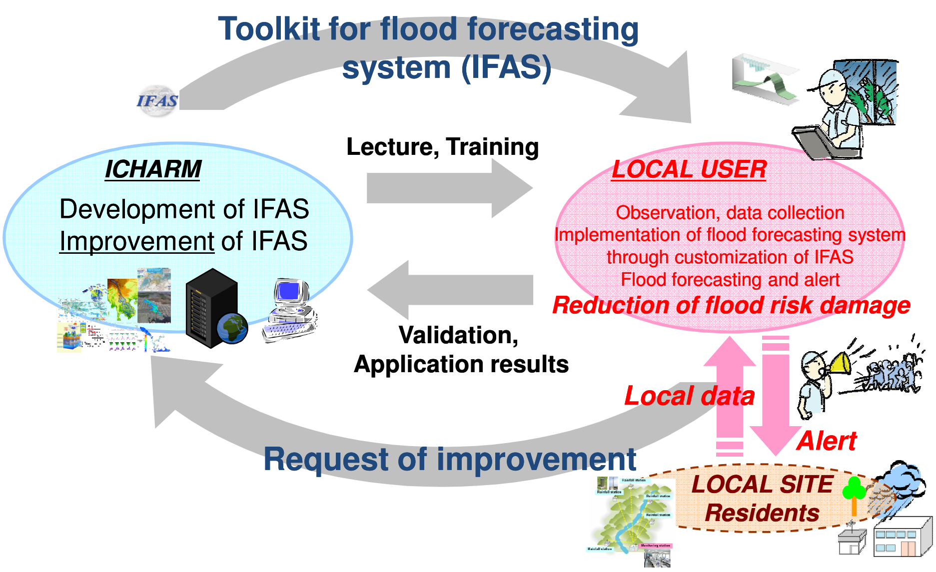
- Purpose of the training course

  To build capacities to undertake hydrological prediction/forecasting in relatively ungauged basins using satellite-based rainfall.

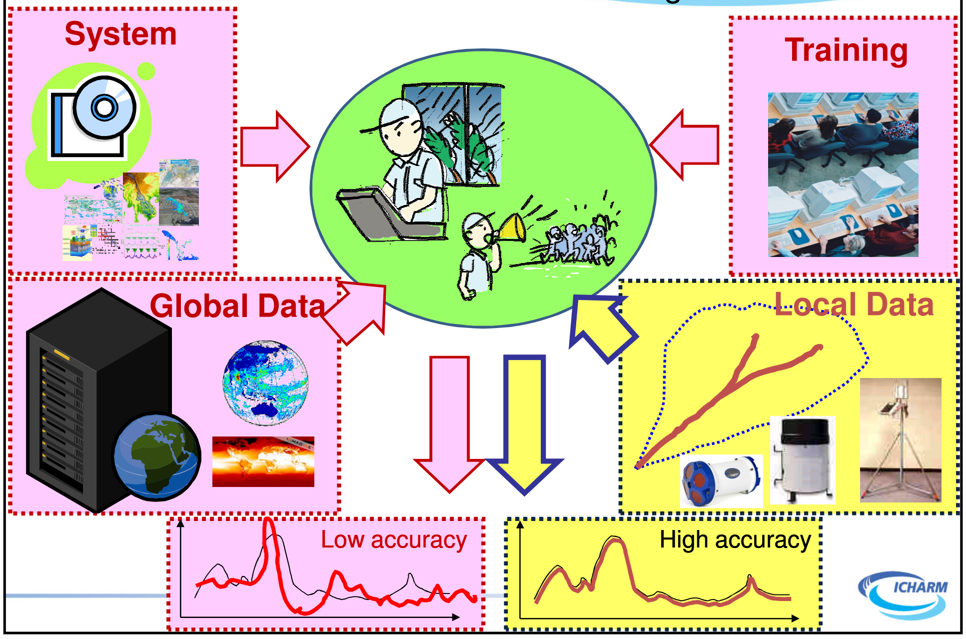
Program
- •Remote Sensing of Precipitation from Space (JAXA)
- •Introduction of river administration in Japan
- •Introduction of Global Flood Alert System
- •Operating procedures for IFAS
- •Validation method of satellite-based rainfall
- •Current conditions and problems in each country

- 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 more (2011)

- ICHARM Master Course, JICA short courses, etc.



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



Conclusion

- The combination of satellite-based rainfall information, global GIS data and IFAS (Integrated Flood Analysis System), as a practical toolkit for local users, especially in poorly-gauged river basins to integrate all those global information, has very high potential to promptly & efficiently implement flood analysis & forecasting system, in consideration with further step-by-step improvements in the future.
- Key valuable information can be acquired through satellite-based and global-GIS-based IFAS simulations even if the accuracy is not enough from the perspective of the coincidence of hydrograph.
- On the other hand, it should be also noted that, without any in-situ (ground-truth) data, such integrated information & analysis cannot be assured, verified nor improved.
- It is, therefore, indispensable to couple satellite & global GIS data with in-situ (geographical, geophysical and hydrologic) data in order to improve the quality (accuracy) of the integrated information & analysis and to upgrade the range & depth of application, which will lead to the establishment of local ownership of flood forecasting and warning.

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