Utilization of Satellite Precipitation Data for Flood Management

Toshiro SUZUKI

Director, Water and Environment Research Department

Infrastructure Development Institute (IDI) – Japan

Contents

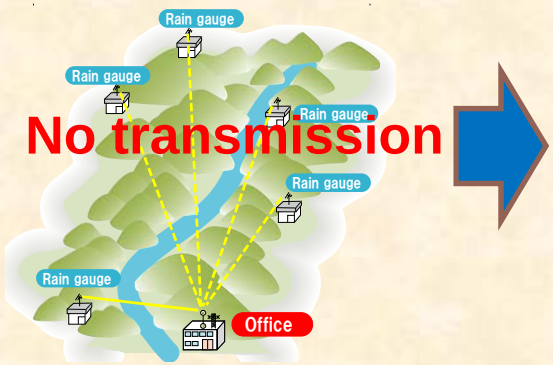
Background

Problems of hydrological observation and data collection for flood warning and forecasting

- *Difficulty to get real-time hydrological data on the river basin*
- *Insufficient installation and maintenance of ground observatory stations with real-time information network (rainfall, water level, flood discharge…).*
- *Lack of data and model for flood warning and forecasting.*
- *Limited budget and human resources for installation and maintenance of observatory station, flood warning and forecasting.*
- *Insufficient framework to enhance technical skill and capacities.*

-> Satellite monitoring can supplement and/or substitute ground observation for flood warning and forecasting, applicable to anytime, anywhere of the world.

Rainfall observation by hand



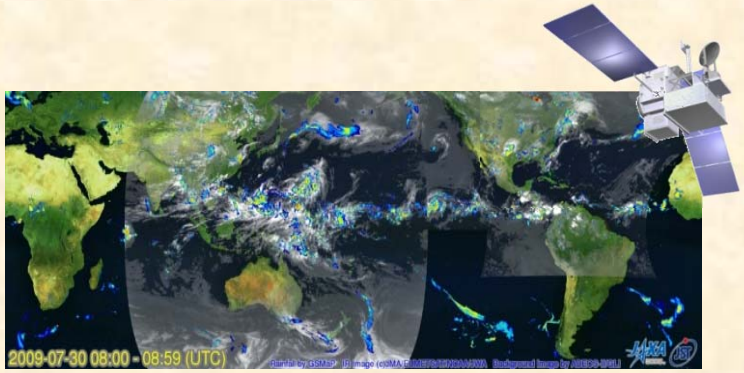
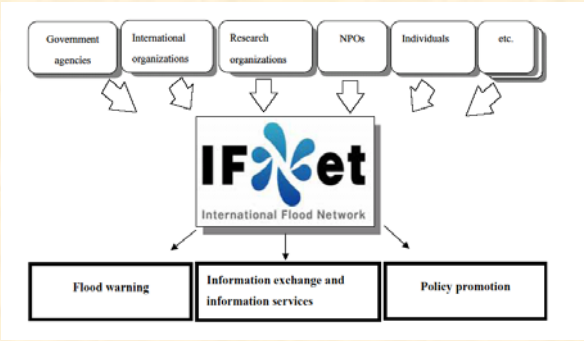


Image Source : JAXA

IFNet (International Flood Network)

GFAS



Background

- *Rising trend of flood damages*
- *View of flood issues as locally limited problems*
- *Few networks that dedicated to flood issues*
- *Necessity to give priority to flood issues*

IFNet was set up as an open network everyone can join on the flood day of WWF3 in 2003.

Objectives

To contribute to flood disaster reduction by:

- ***Sharing** knowledge and lessons,*
- ***Promoting** good practices,*
- ***Raising** awareness on flood risk among policy makers & citizen.*

Membership

- *IFNet is an open, free network to everyone, currently 634 registered from 83 countries (as of 31 December, 2012).*
- *Advantage: Opportunity to receive GFAS information*

Schematic figure of GFAS

GFAS

i) Space agencies

Satellite observation

Heavy rainfall in the river basin

River

ii) IDI-Japan

Download of data

⇩

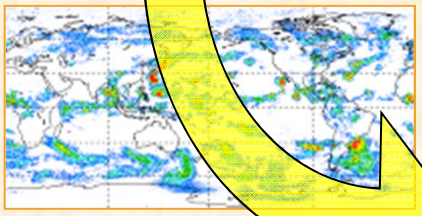
Data processing

⇩

Mapping, Email

System development

iv) Hydrological service to river authorities



iii) IFNet

1. **IFNet Homepage**
2. **Email of heavy rain information to IFNet members in charge of flood forecasting and warning**

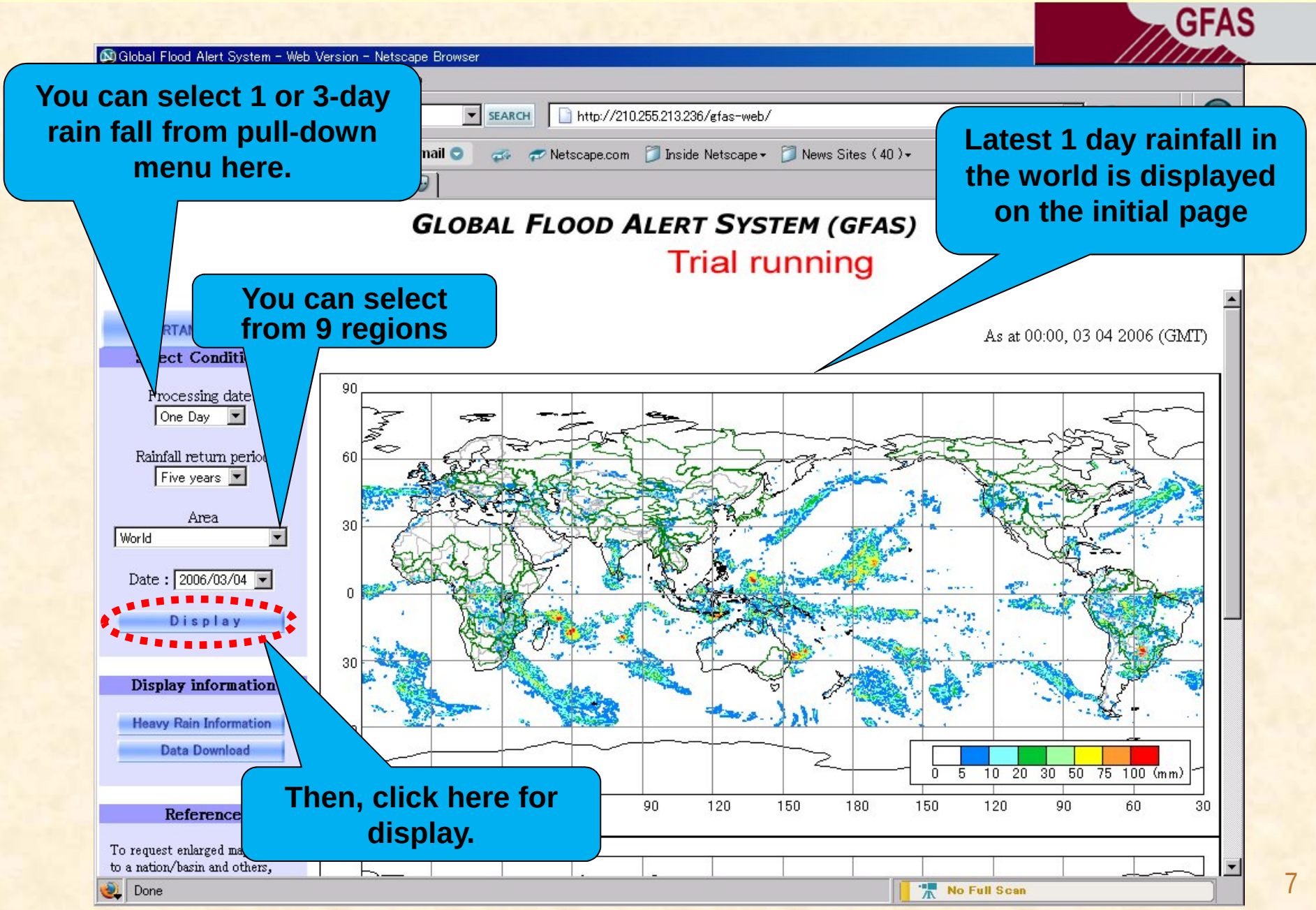
Flood warning and forecasting by using GFAS Information etc.

v) Residents/ NGOs/ Community leaders

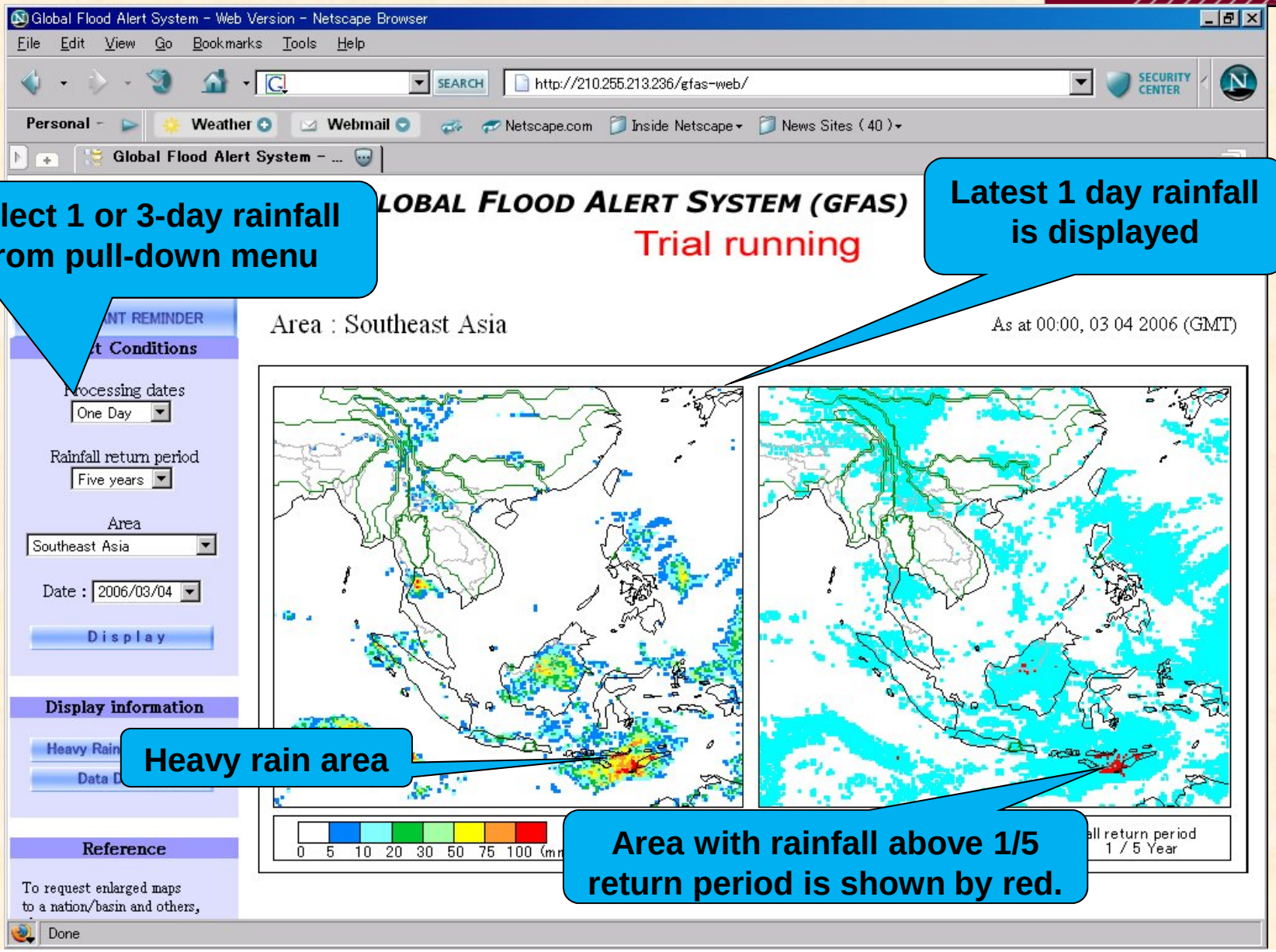
Website of IFNet & GFAS

IFNeT Homepage: http://www.internationalfloodnetwork.org/

Precipitation data of the world by using satellite monitoring



GFAS : Daily precipitation data - Example of Southeast Asia

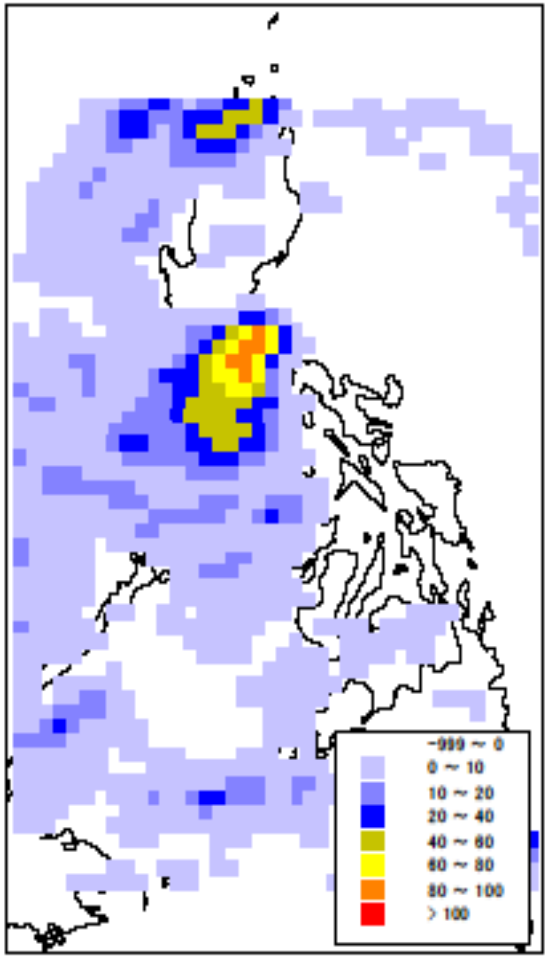


GFAS Up-grading 3B42RT >>> GSMaP

Typhoon Ketsana on the Philippines (2009/09/26 daily)

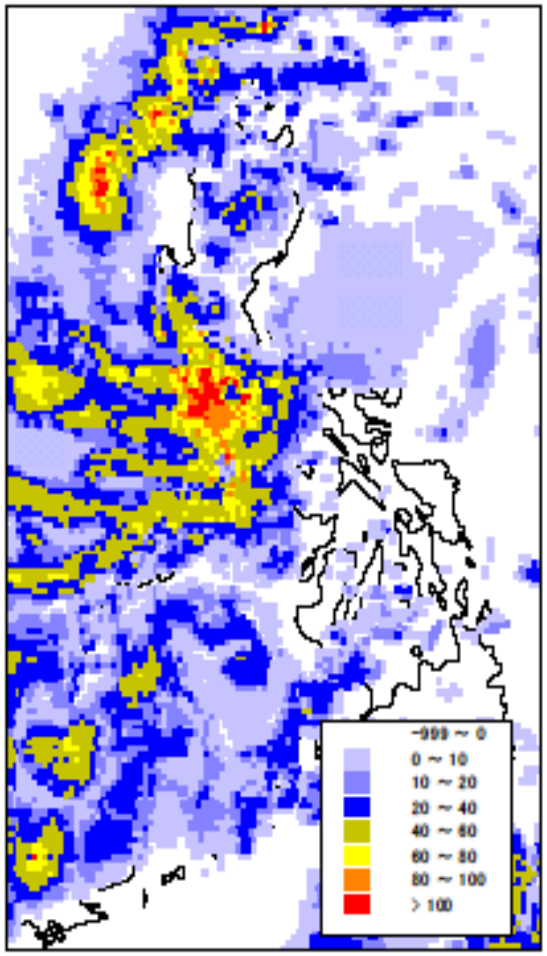
3B42RT (1998-2008)

- *Mesh size: 0.25°*
- *data delay: 10 hours*



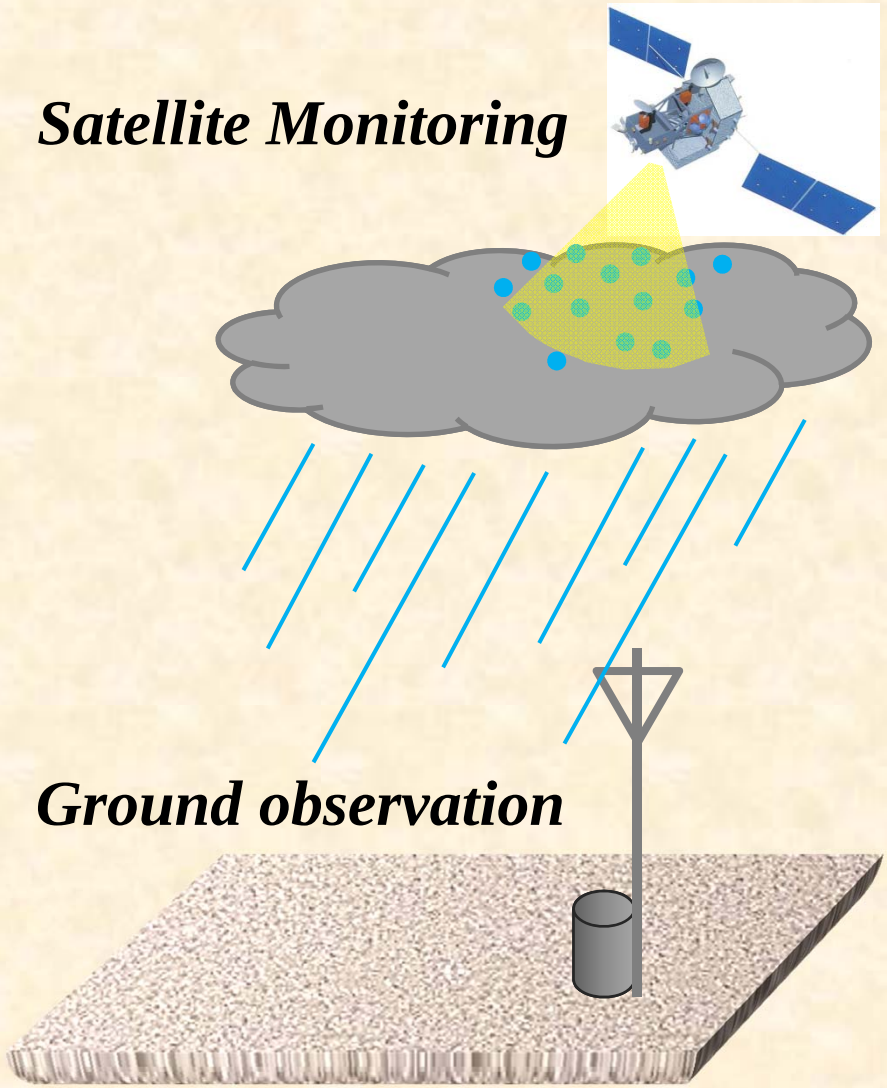
GSMaP (2007-)

- *Mesh size: 0.1° (10x10 km²)*
- *data delay: 4 hours*



Up-grading from 3B42RT to GSMaP enabled more detailed and more rapid transmission of precipitation data.

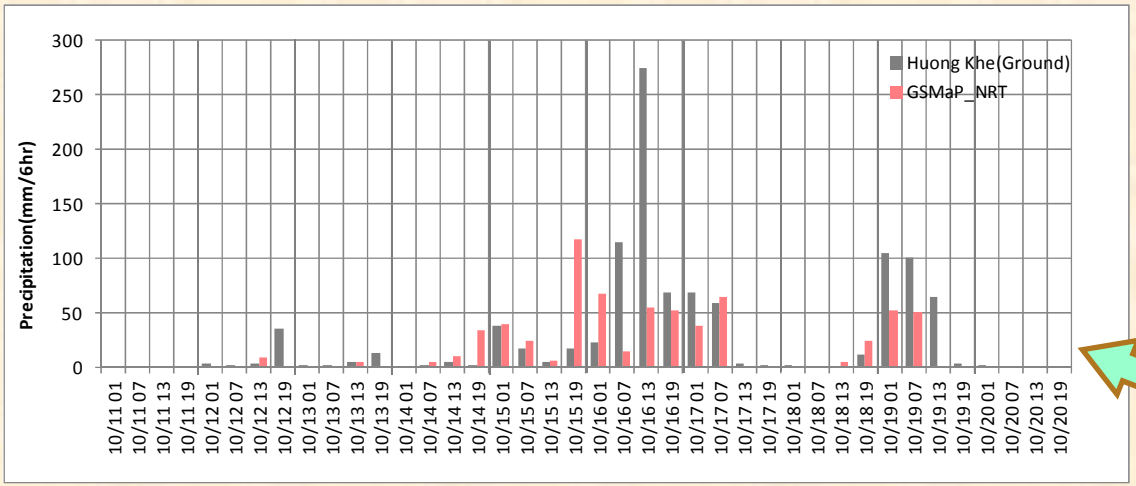
2. GFAS Development (1): Correlation between satellite monitoring and ground observation



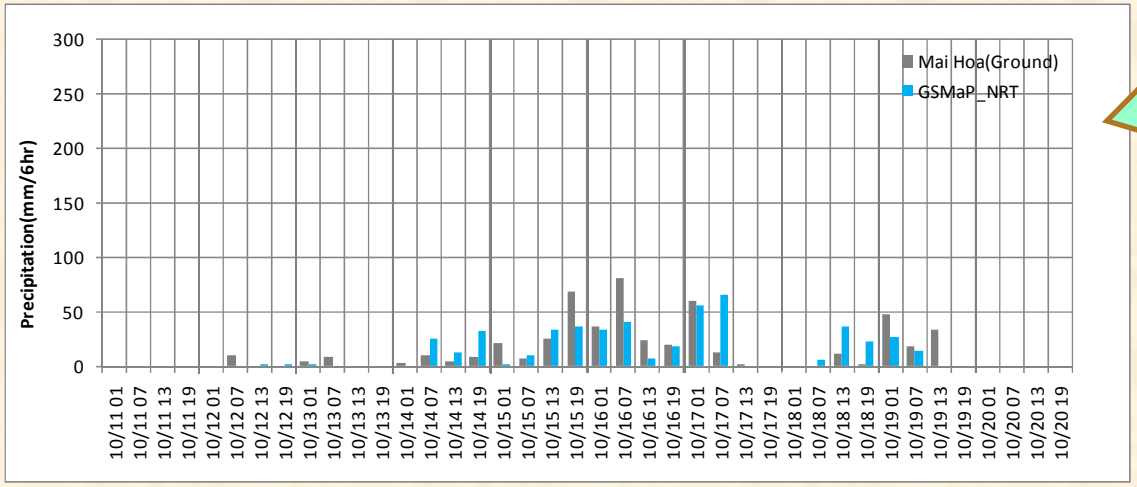
In order to estimate ground precipitation, correlation between satellite monitoring data and ground precipitation data has been studied.

Pilot study areas:
Huong Khe (Ha Tinh),
Mai Hoa (Quang Binh)

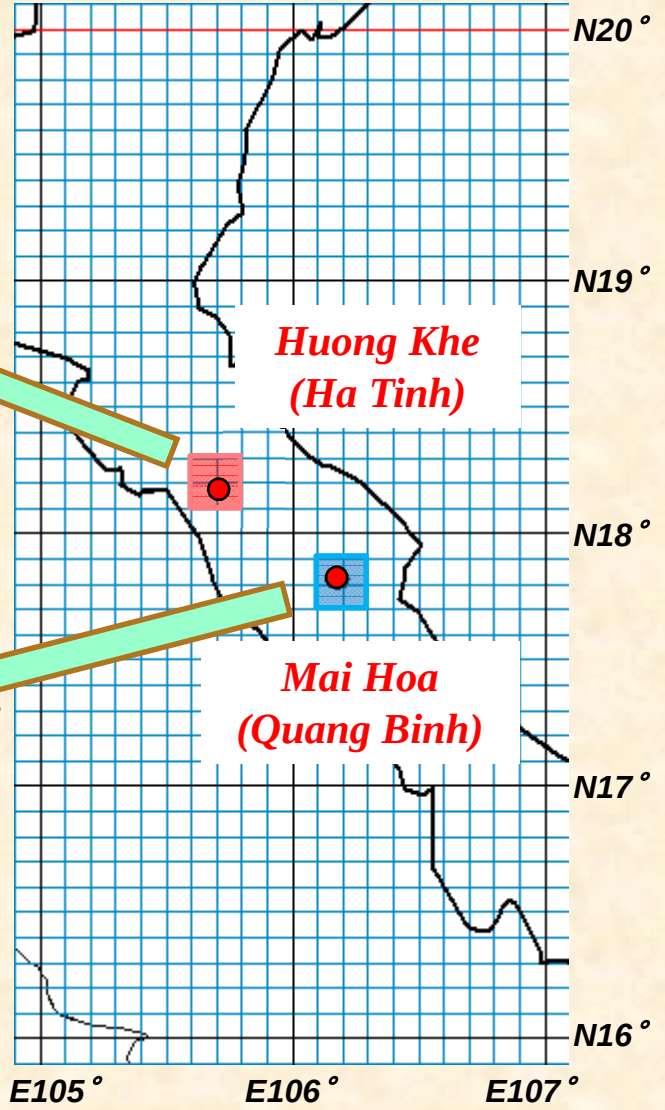
6-hours precipitation 2010/10/11-10/20



***Huong Khe, Ha Tinh* (R=0.158)**

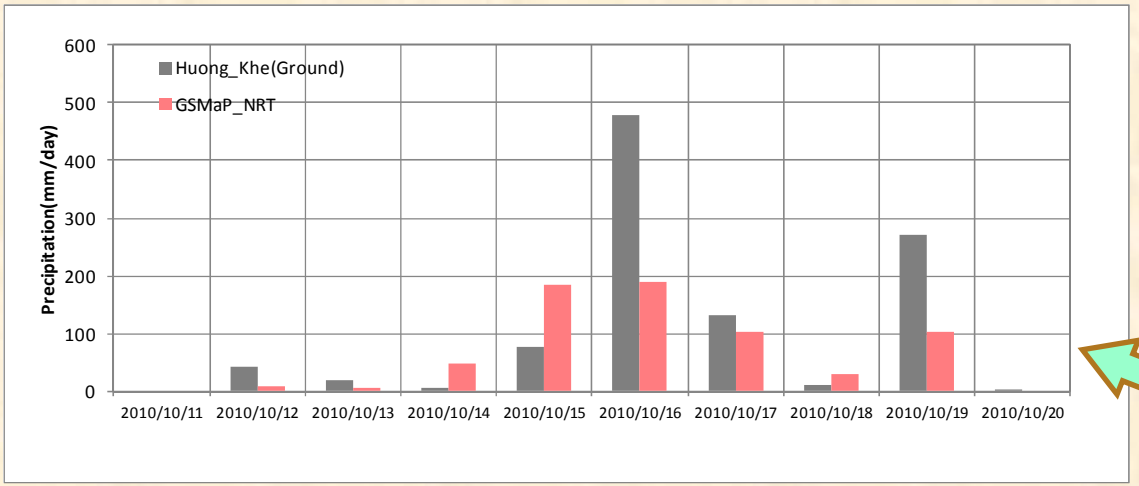


***Mai Hoa, Quang Binh* (R=0.499)**

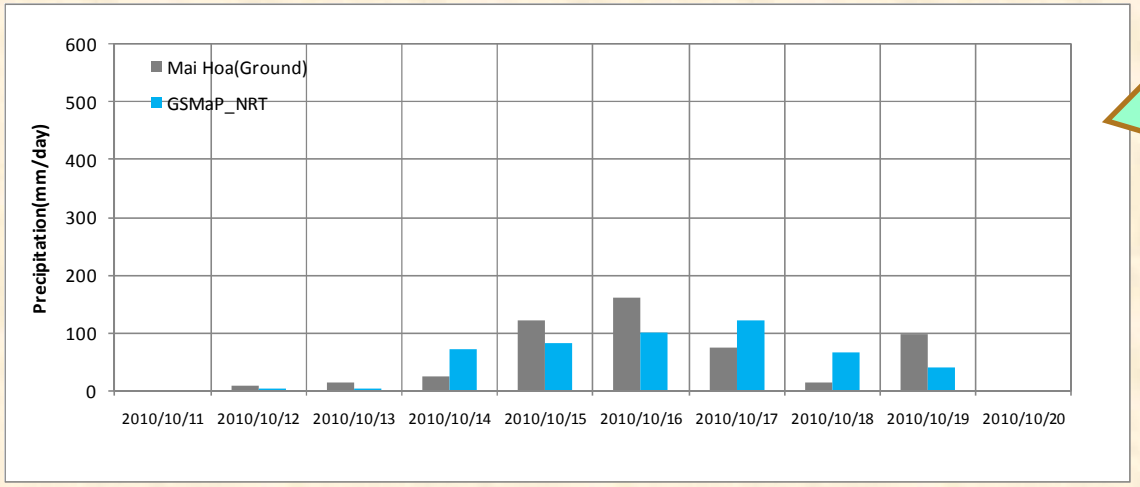


Note: GSMaP_NRT data is the maximum one among the four mesh data. (□□)

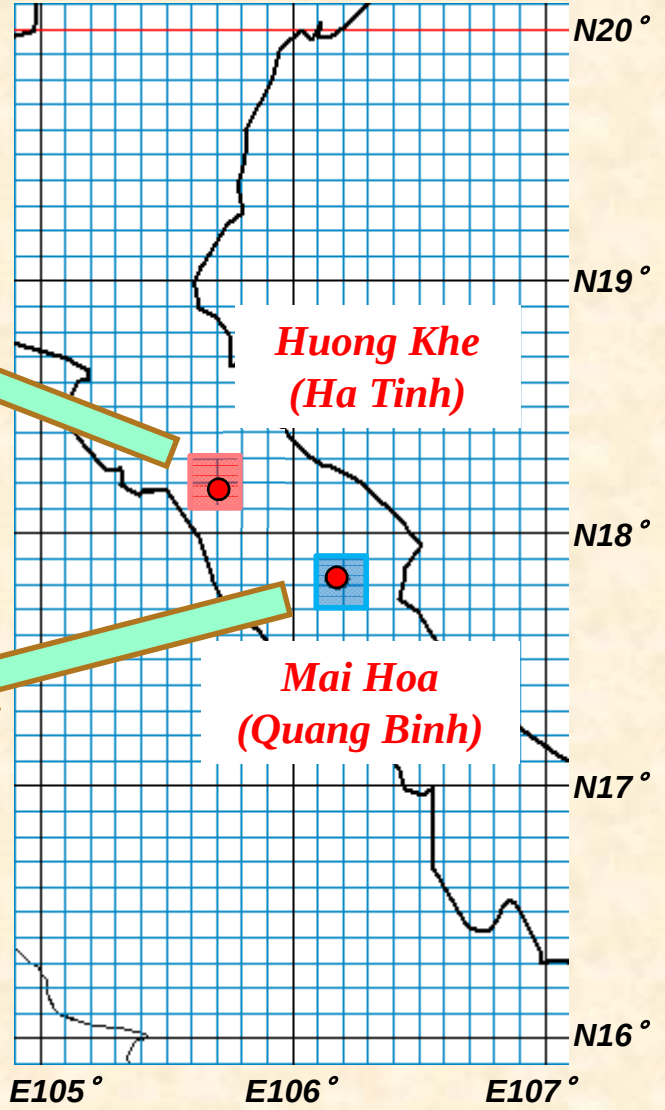
1-day precipitation 2010/10/11-10/20



***Huong Khe, Ha Tinh* (R=0.598)**

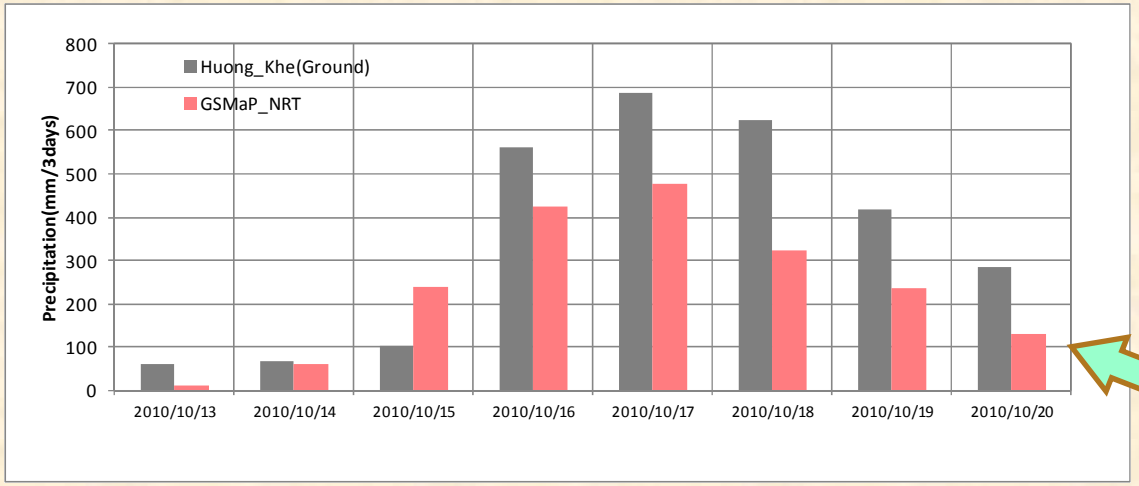


***Mai Hoa, Quang Binh* (R=0.306)**

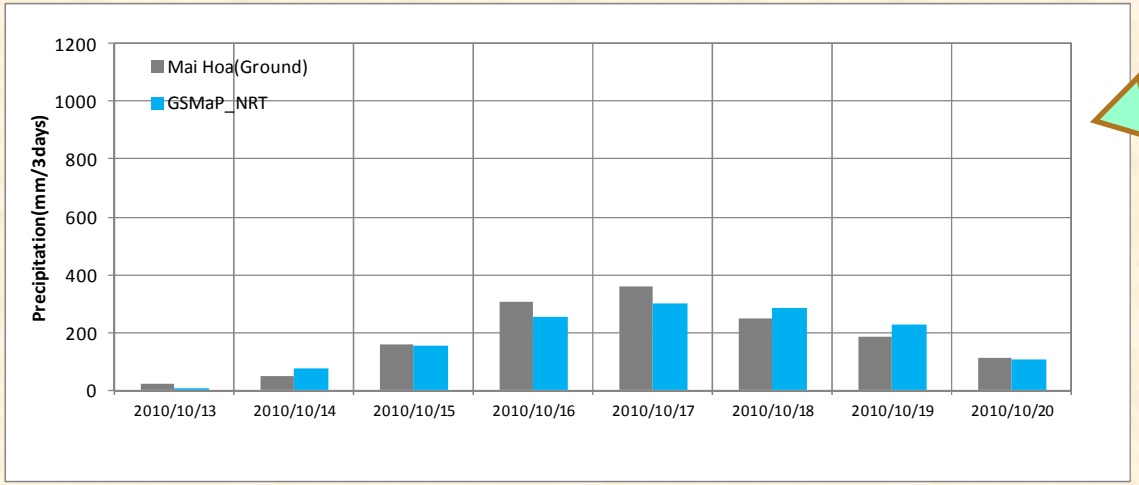


Note: GSMaP_NRT data is the maximum one among the four mesh data. (□□)

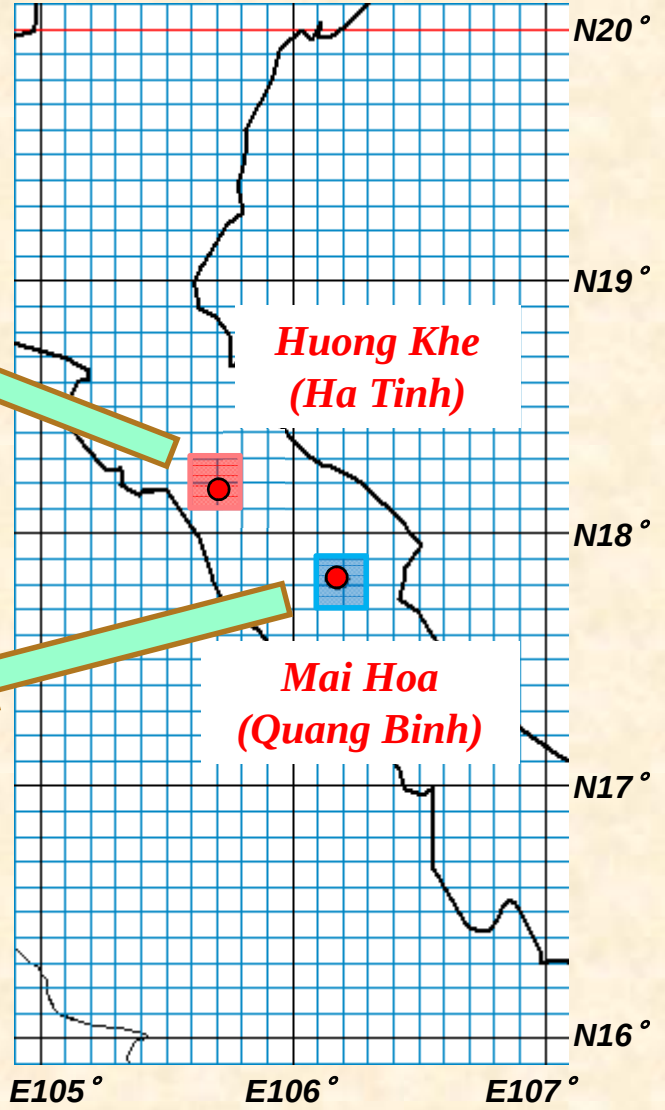
3-days precipitation 2010/10/11-10/20



***Huong Khe, Ha Tinh* (R=0.881)**



***Mai Hoa, Quang Binh* (R=0.942)**



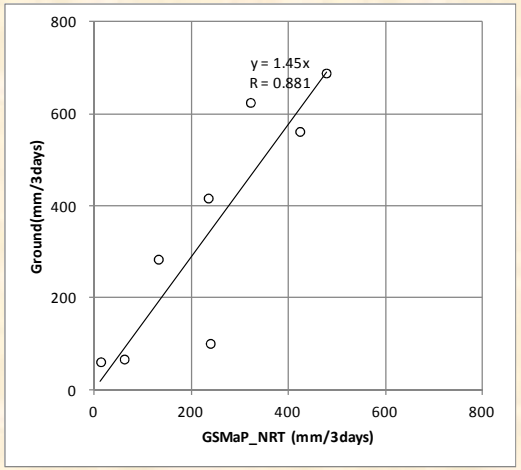
Note: GSMaP_NRT data is the maximum one among the four mesh data. (□□)

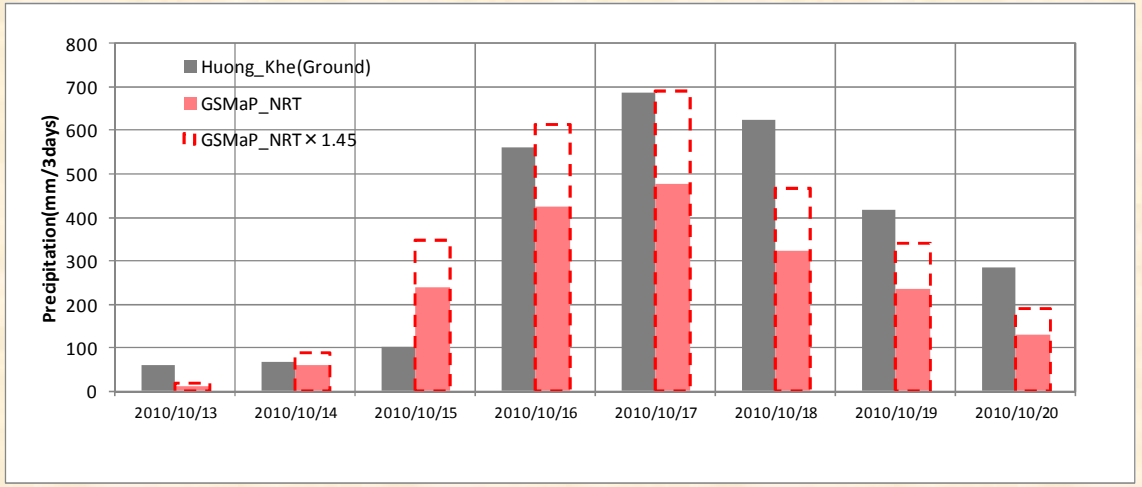
Estimation of ground precipitation by using satellite monitoring data

correlation coefficient between ground data and satellite data

	Huong Khe	Mai Hoa
6-hours precipitation	0.158	0.499
1-day precipitation	0.598	0.306
3-days precipitation	**0.881**	**0.942**

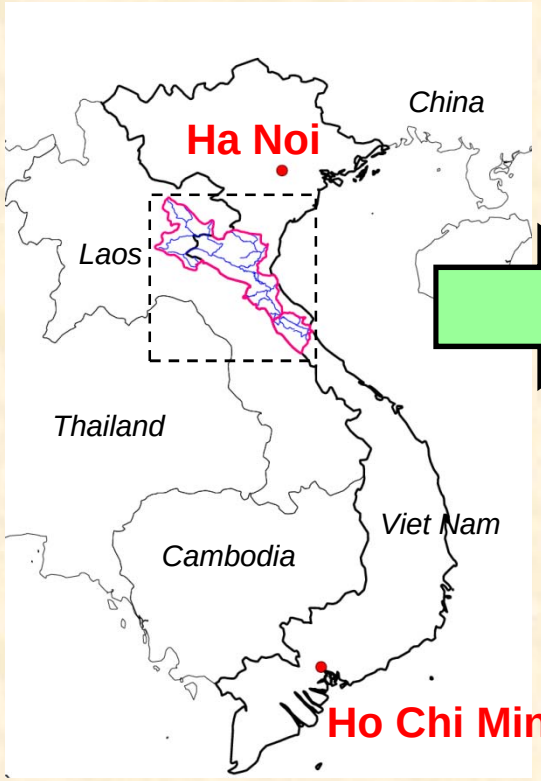
Ground precipitation can be estimated by using the satellite monitoring data, considering the high correlation coefficient of 3-days precipitation data.

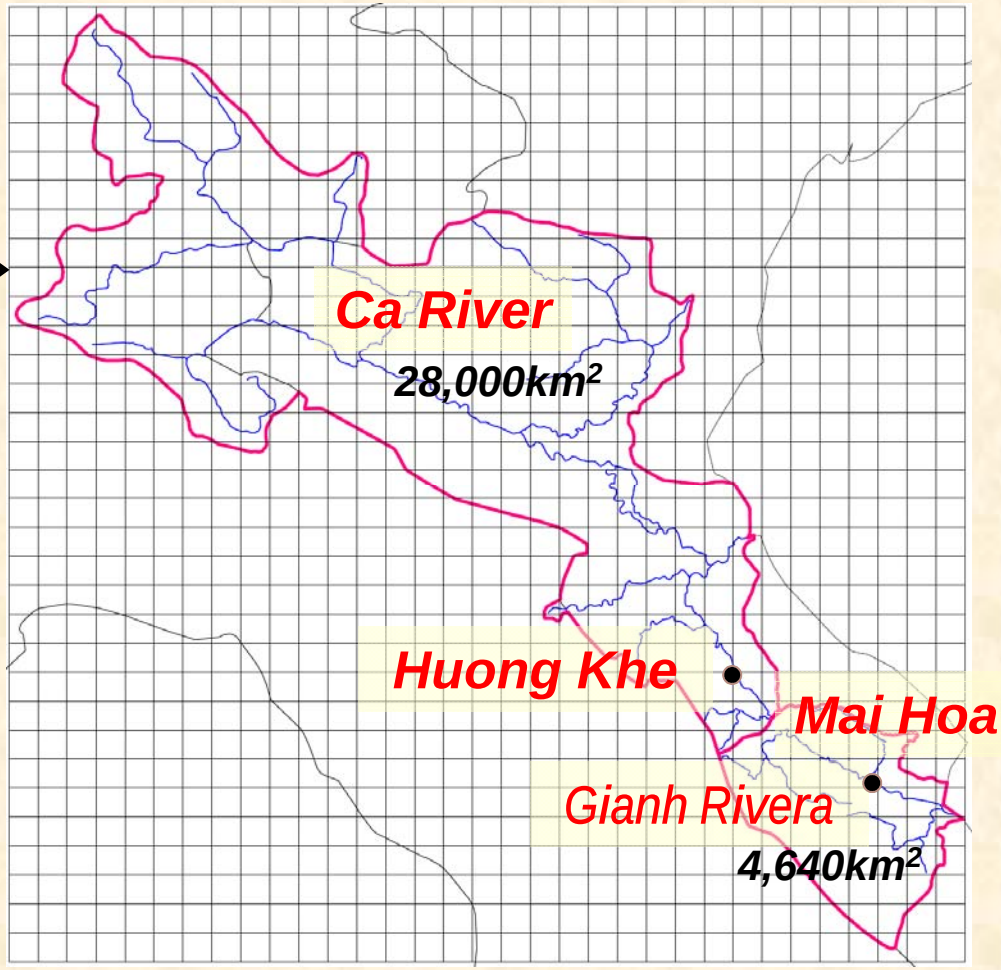




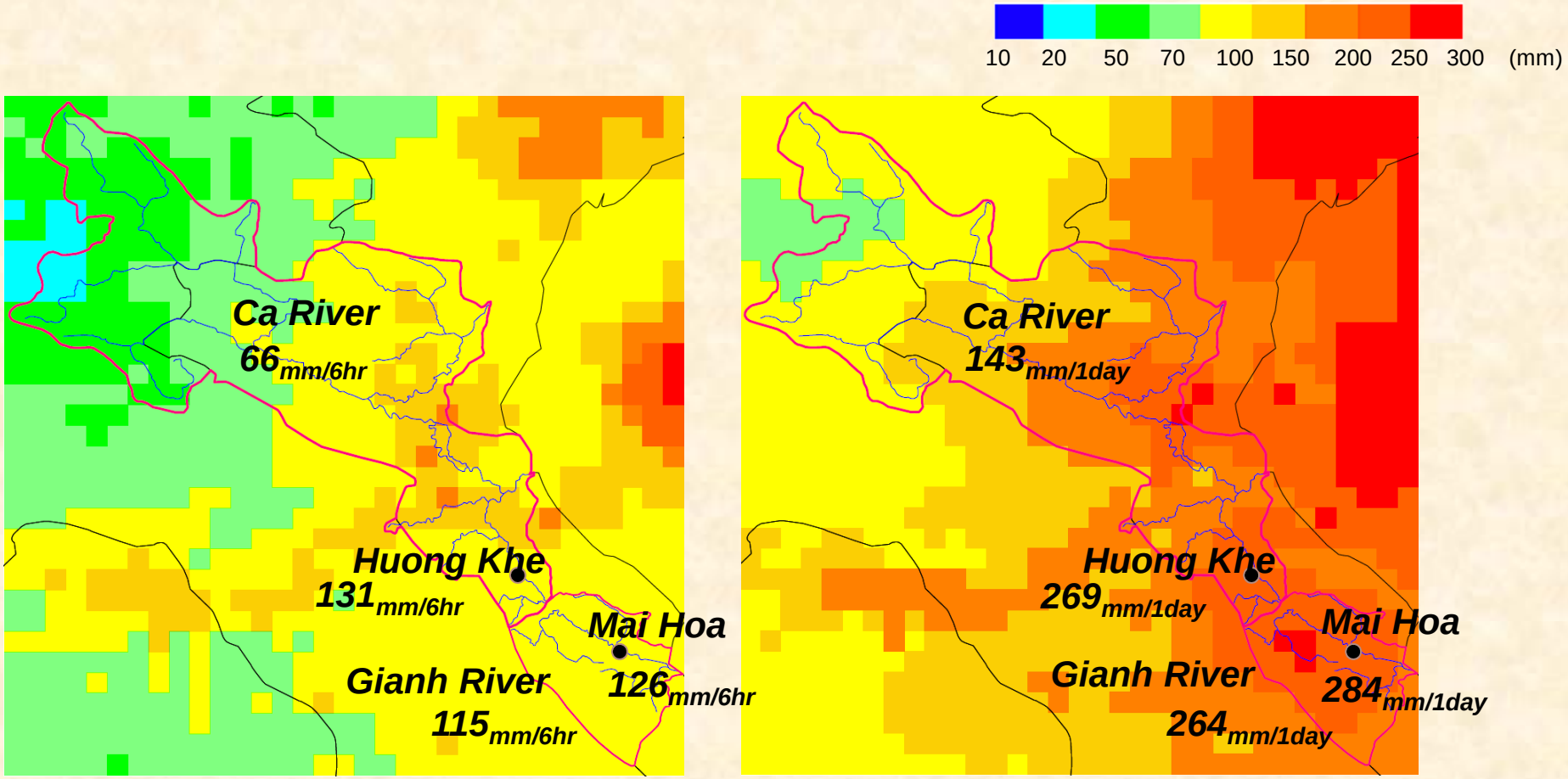
2. GFAS Development (2): Estimation of probable precipitation with return period (1/3, 1/5, 1/10…)

Pilot Areas :Huong Khe, Ca River Basin
Mai Hoa, Gianh River Basin





6-hours and 1-day precipitation of 10-years return period (1/10)

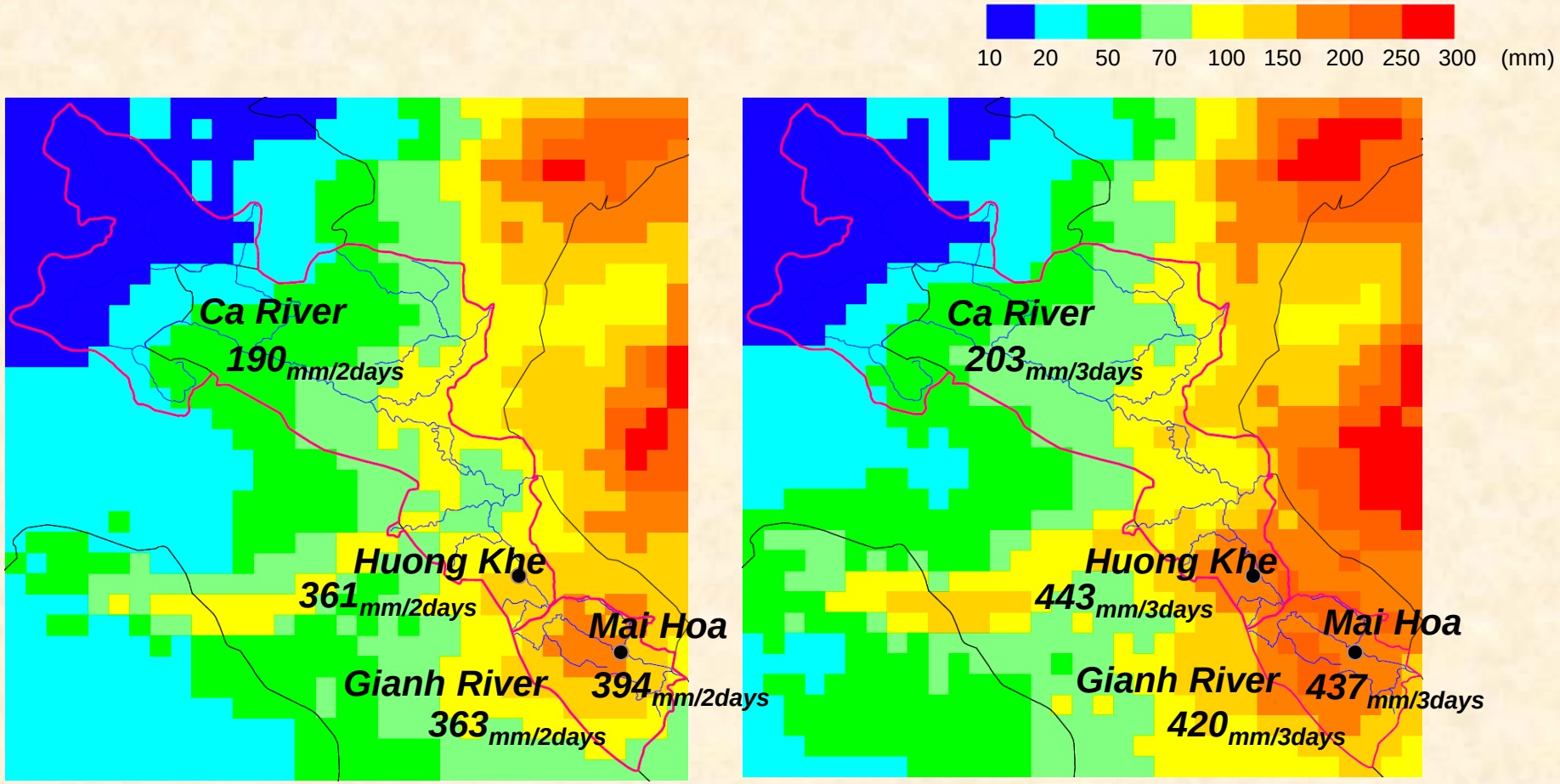


6-hours precipitation

1-day precipitation

Used Data:2003-2011 (9 years)

2-days and 3-days precipitation of 10-years return period (1/10)



2-days precipitation

3-days precipitation

Used Data:2003-2011 (9 years)

Utilization of probable precipitation with return period for flood management

Probable 3-days precipitation of 1/3, 1/5, 1/30… of each river

	Ca River	Gianh River
1/3	156 mm	252 mm
1/5	177 mm	317 mm
1/10	203 mm	420 mm
1/30	243 mm	633 mm
…	…	…

Probable precipitation (1/5, 1/10…) can be calculated from GSMaP data (2003-11)

Alert level can be examined, much better be testified by using the ground observatory data, if available

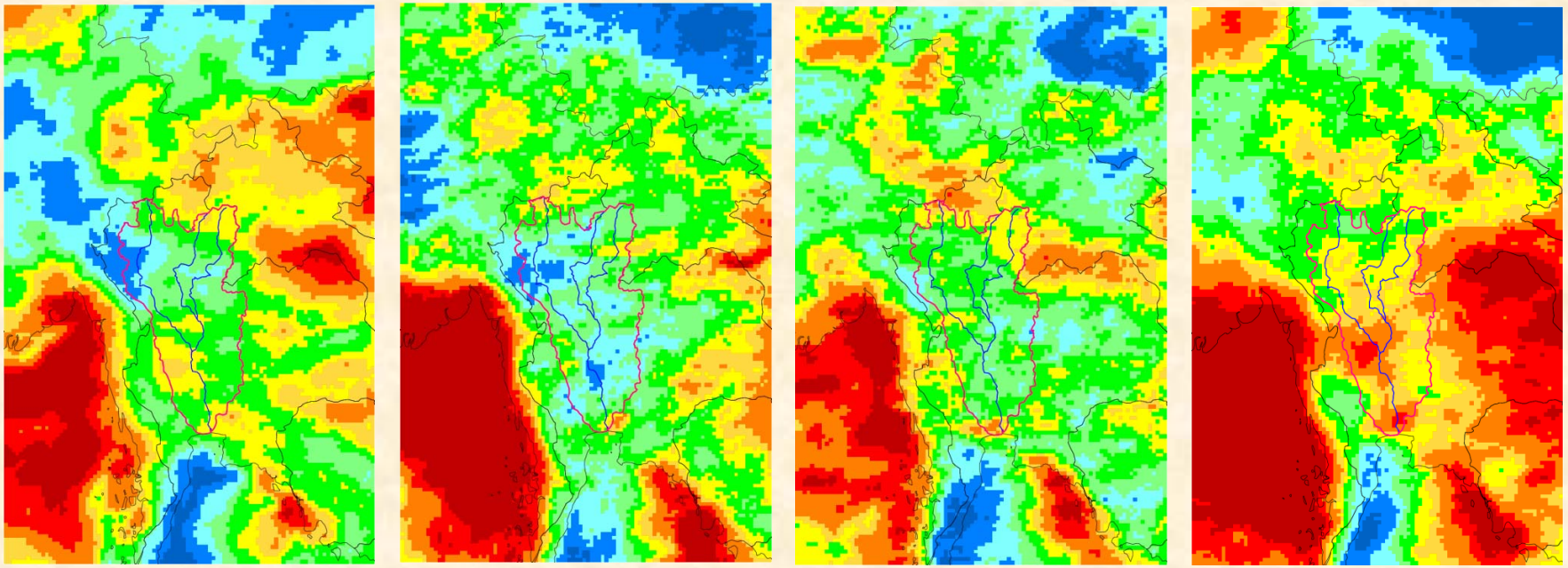
Flood Alert

- **Start of people's evacuation**
- **Preparation for flood defense activities**

3. Flood in the Chao Phraya River, 2011

By using satellite-monitoring data from GSMaP, 3 month's basin-average precipitation (July-September of 2008-2011) were analyzed without using any ground observatory data.

2008 2009 2010 **2011**



Basin mean precipitation in Chao Phraya River Basin from July to September

518mm 424mm 527mm **710mm**

DATA/ GSMaP MVK(2008)
GSMaP NRT(2009-2011)

Monthly precipitation of the Chao Phraya River basin

	2008	2009	2010	Average of 3 years (2008-2010)	2011 (compared to 3 years average)
July	164mm	128mm	147mm	146mm	205mm (140%)
August	164mm	151mm	217mm	177mm	225mm (127%)
September	190mm	145mm	162mm	166mm	279mm (168%)
Total rainfall in 3 months	518mm	424mm	527mm	490mm	710mm (145%)

More rain in July-August of 2011 than those of the previous three years, and much more rain in September.

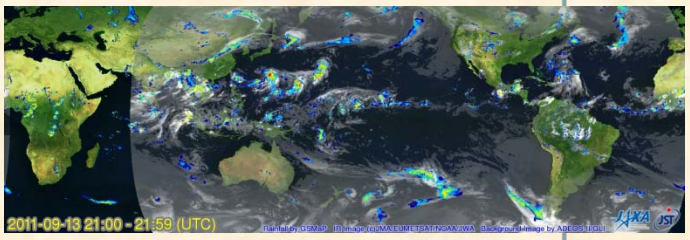
At the end of August, we already knew the precipitation of this year is bigger than the previous ones…

If we knew about this trend in advance, could we foresee today's serious situation? or at least well prepared?

4. Development of Satellite-Based Precipitation Data Delivery System for Thailand

By using the GSMaP data, average precipitation for specific river basin and region (Amphoe) can be calculated.

Also, notification signal can be displayed when the observed basin or regional average precipitation exceeds the pre-calculated probable precipitation with some return periods (for example, once in 5 years).



System Contents

Satellite-based precipitation

Convert precipitation data

Evaluate probable precipitation

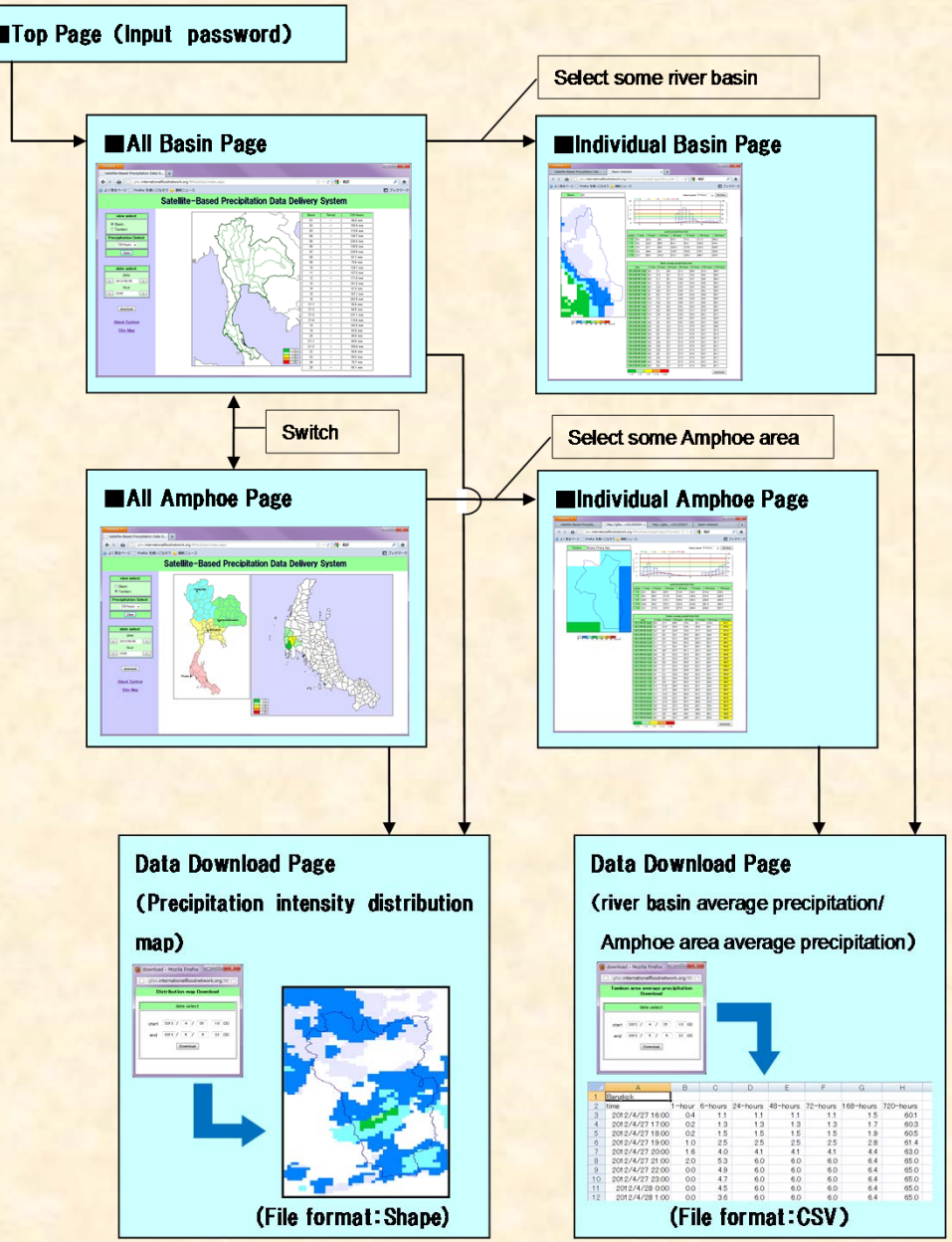
Display on the Website

Satellite-based precipitation is converted to the following precipitations.
- 6hours precipitation
- 1day precipitation
- 2days precipitation
- 3days precipitation
- 1week precipitation
- 1month precipitation

One can obtain information on the intensity of precipitation by comparing the observed data with the pre-calculated probability data.
For example, one can obtain such information as "The observed precipitation is greater than the probable precipitation of once in 5 years.".

System configuration

- A password will be required to enter the top page.
- Select the individual basin from all basin page.
- You can switch from all basin page to all Amphoe page.
- Select the individual Amphoe from all Amphoe page.
- You can download the distribution map at all basin and Amphoe page.
- You can download the average precipitation data at individual basin and Amphoe page .



System operation – Basin page <1/2>

■ All basin page

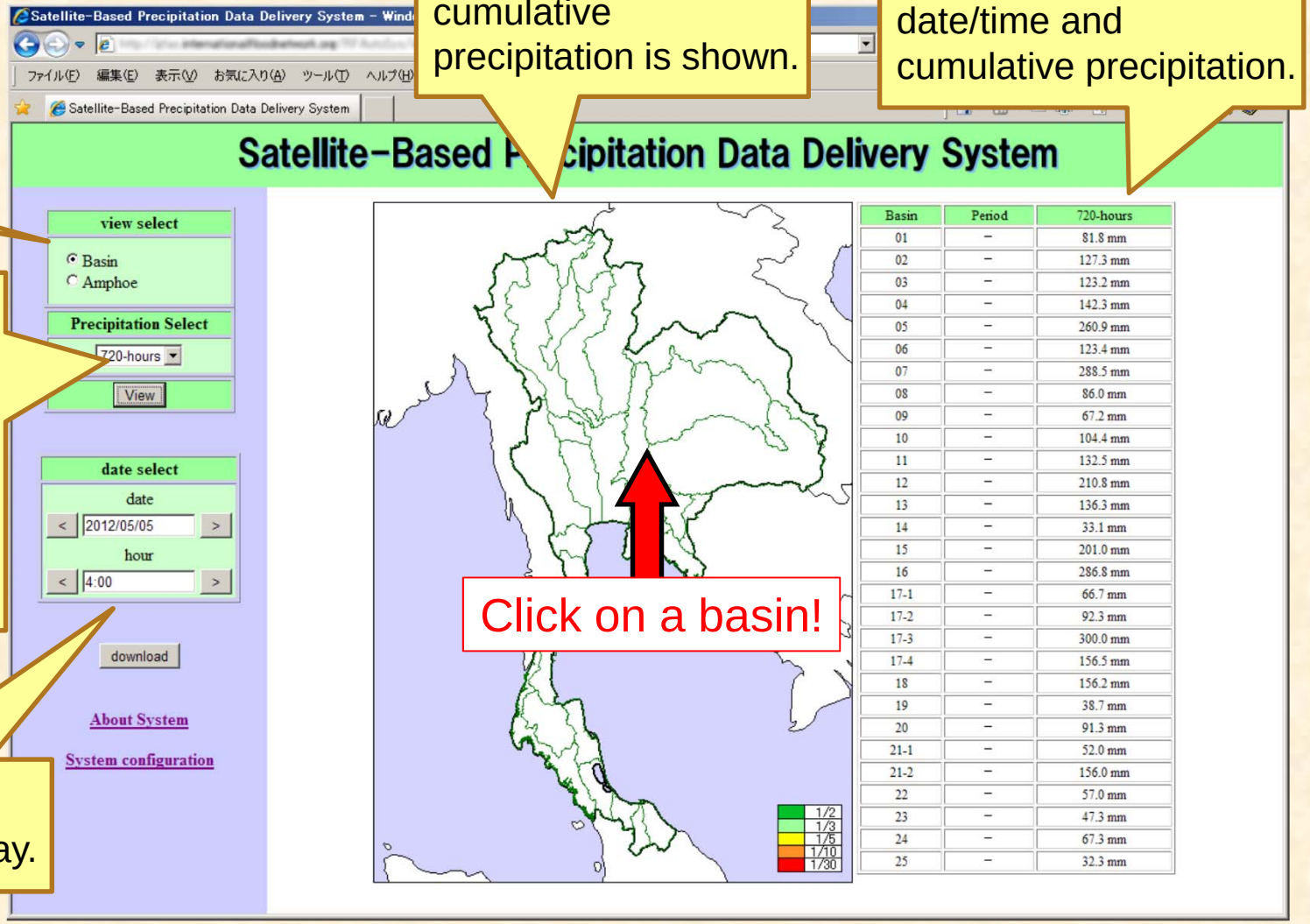
Distribution map of cumulative precipitation is shown.

Precipitation data is shown for the selected date/time and cumulative precipitation.

Select Basin or Amphoe.

Select precipitation.
- 1 hour
- 6 hours
- 1 day
- 2 days
- 3 days
- week
- month

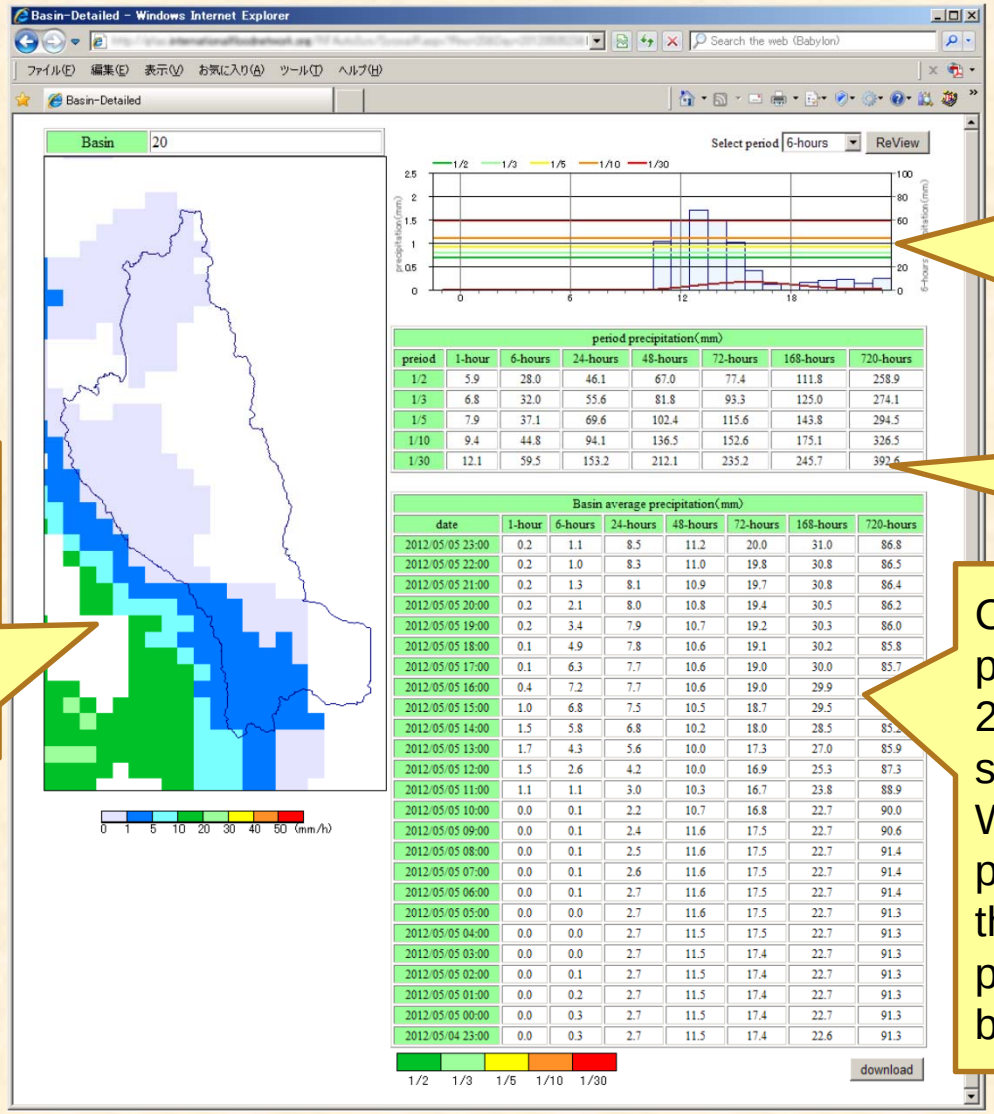
Select date and time(hour) to display.



Basin	Period	720-hours
01	–	81.8 mm
02	–	127.3 mm
03	–	123.2 mm
04	–	142.3 mm
05	–	260.9 mm
06	–	123.4 mm
07	–	288.5 mm
08	–	86.0 mm
09	–	67.2 mm
10	–	104.4 mm
11	–	132.5 mm
12	–	210.8 mm
13	–	136.3 mm
14	–	33.1 mm
15	–	201.0 mm
16	–	286.8 mm
17-1	–	66.7 mm
17-2	–	92.3 mm
17-3	–	300.0 mm
17-4	–	156.5 mm
18	–	156.2 mm
19	–	38.7 mm
20	–	91.3 mm
21-1	–	52.0 mm
21-2	–	156.0 mm
22	–	57.0 mm
23	–	47.3 mm
24	–	67.3 mm
25	–	32.3 mm

System operation – Basin page <2/2>

■ Individual Basin Page



Cumulative precipitation and hourly precipitation are shown on a graph.

Probable precipitation is shown in a table.

The screen displays the satellite-based hourly precipitation of the selected date.

Cumulative precipitation is shown 24hr before the selected time/date. When the observed precipitation exceeds the probable precipitation, the cell becomes to be colored.

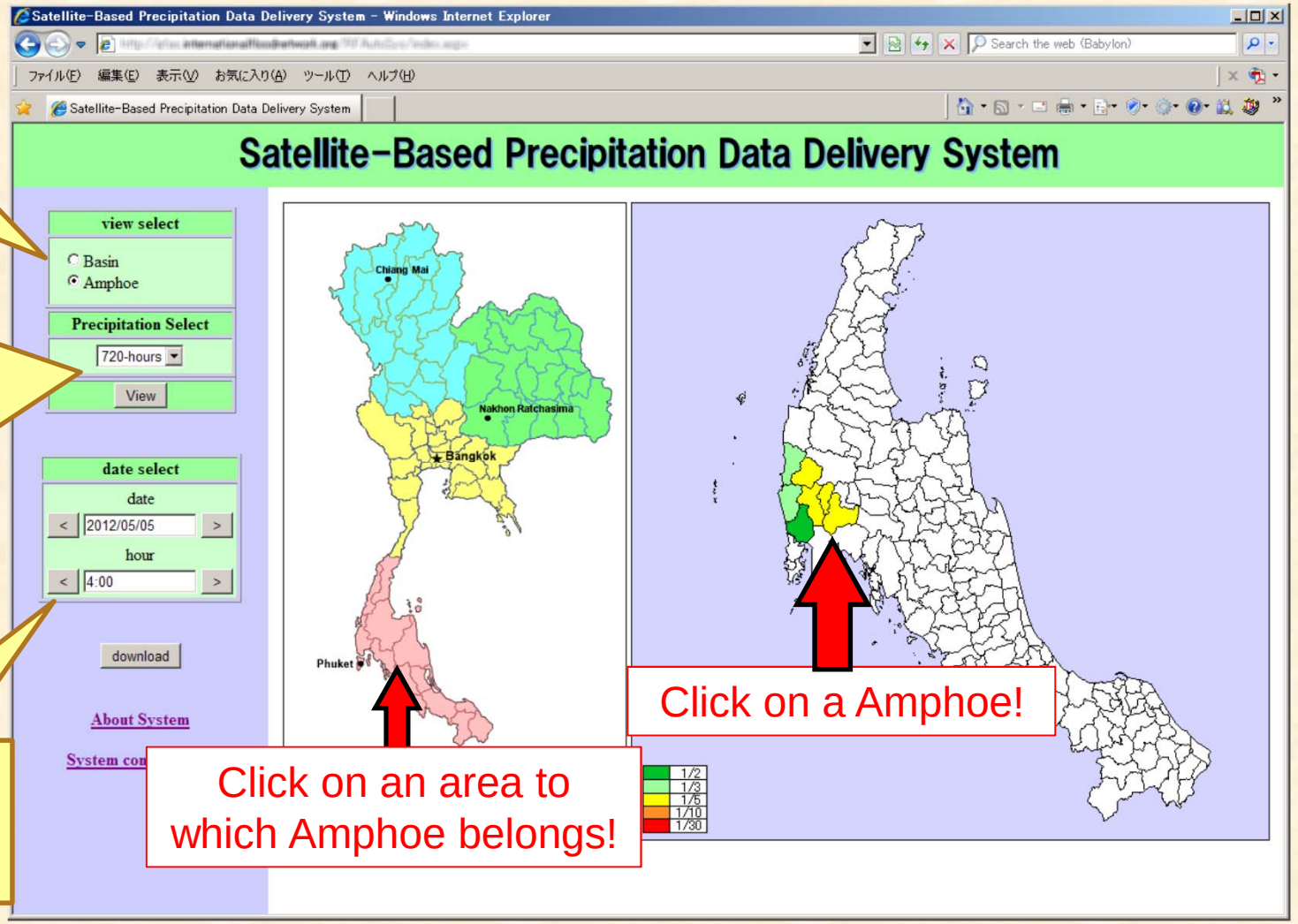
System operation – Amphoe page <1/2>

■ All Amphoe Page

Select Basin or Amphoe.

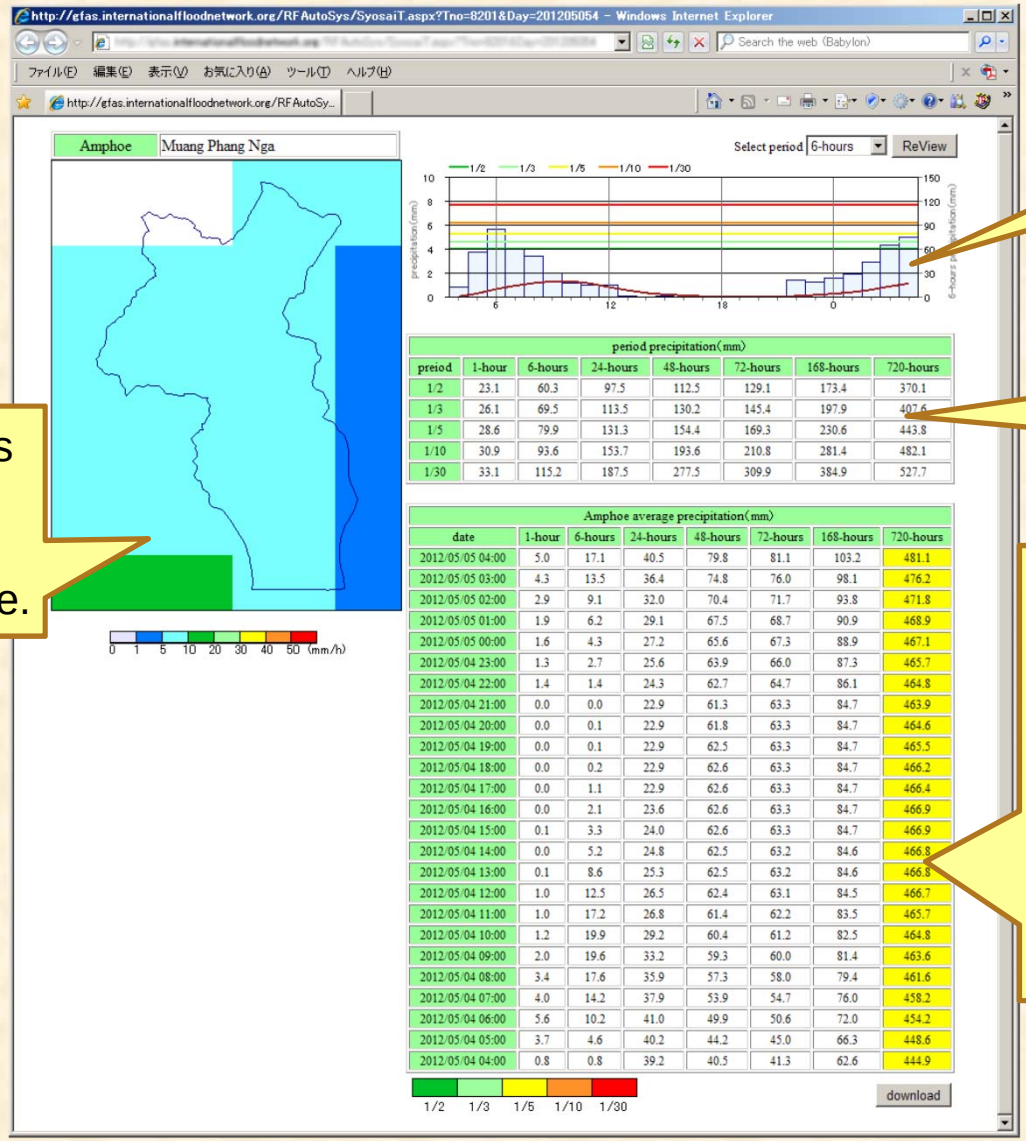
Select precipitation
- 1 hour
- 6 hours
- 1 day
- 2 days
- 3 days
- week
- month

Select date and time(hour) to display.



System operation – Amphoe page <2/2>

■Individual Amphoe Page



Cumulative precipitation and hourly precipitation are shown on a graph.

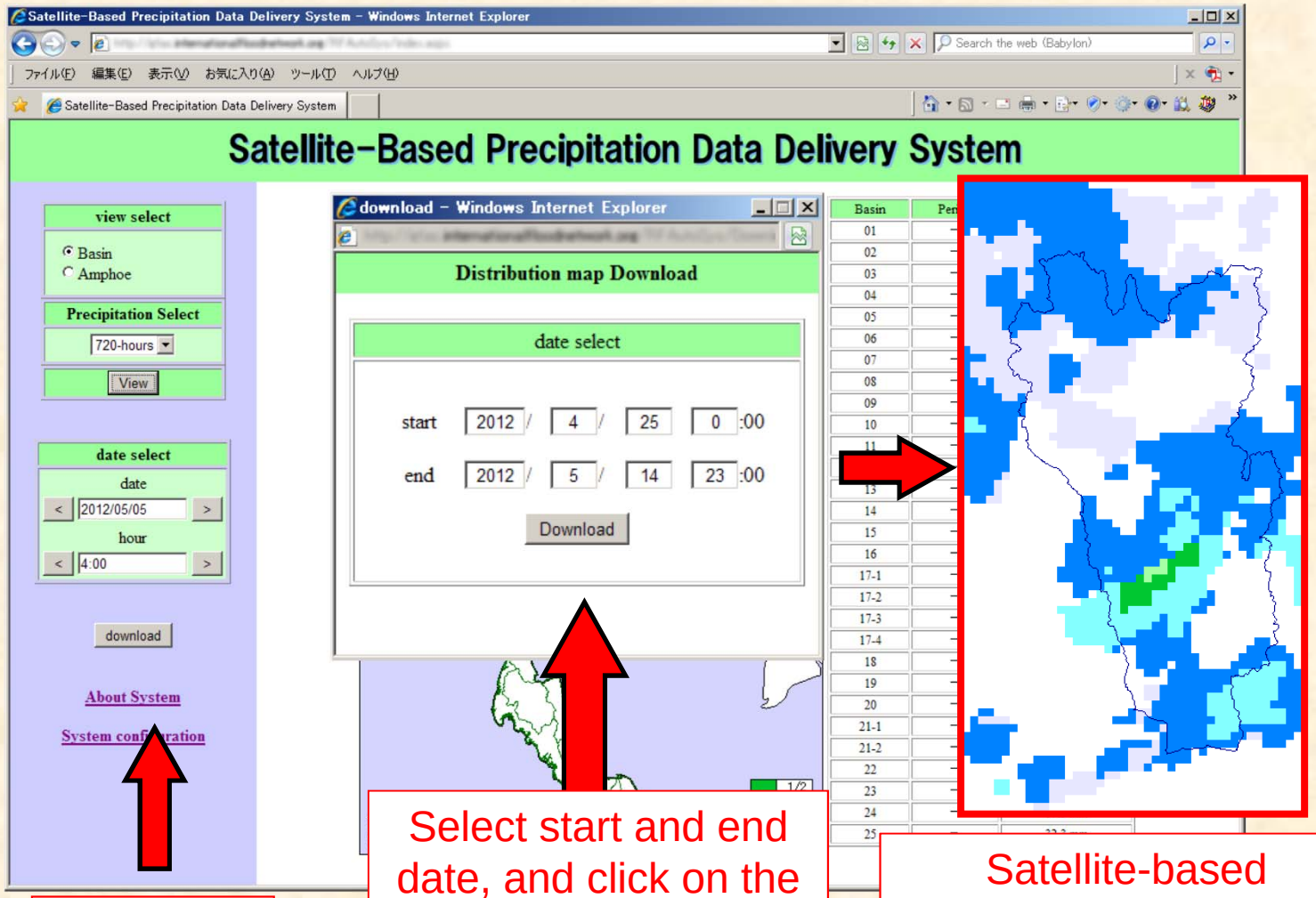
Probable precipitation is shown in a table.

The screen displays the satellite-based hourly precipitation of the selected date.

Cumulative precipitation is shown 24hr before the selected time/date. When the observed precipitation exceeds the probable precipitation, the cell becomes to be colored.

System operation – Data Download page <1/2>

■Data Download Page（Precipitation intensity distribution map）



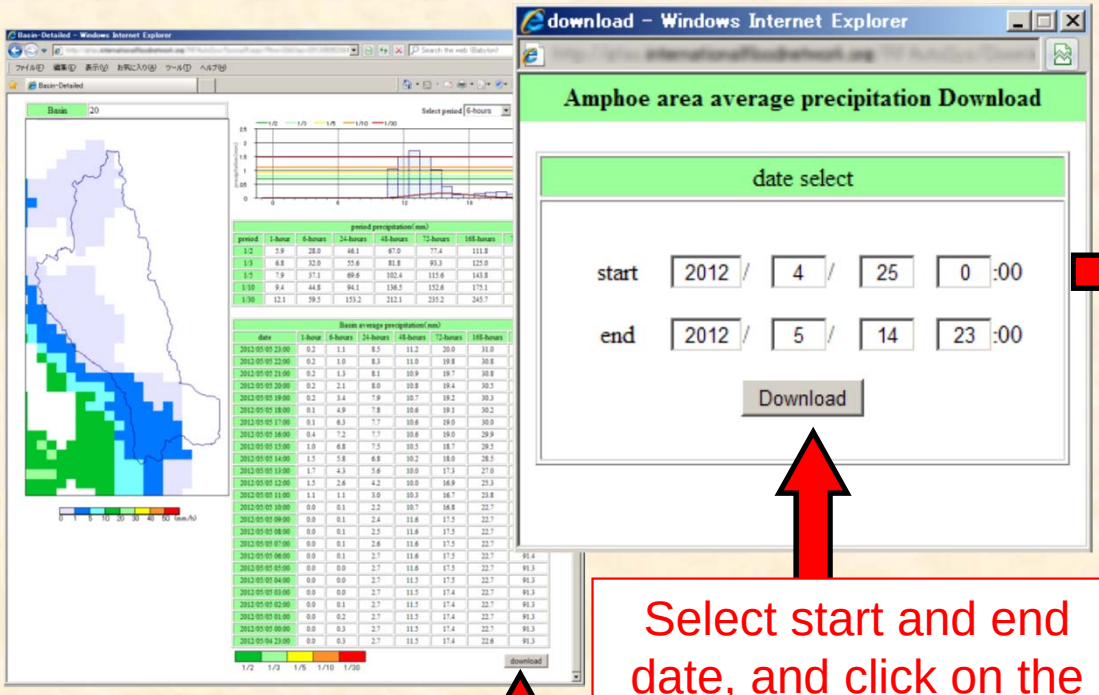
Click ！

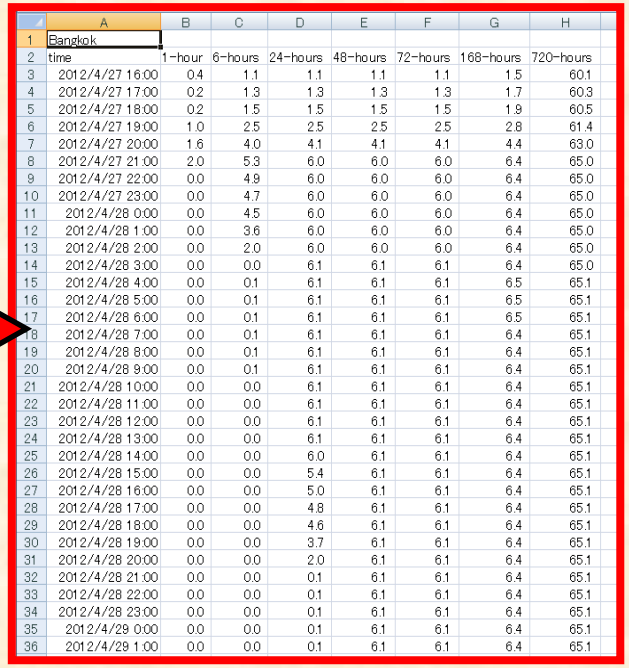
Select start and end date, and click on the ” Download”button!

Satellite-based precipitation data (shp file) is downloaded.

System operation – Data download page <2/2>

■Data Download Page
（Precipitation data for specific river basin and Amphoe）





	A	B	C	D	E	F	G	H
1	Bangkok							
2	time	1-hour	6-hours	24-hours	48-hours	72-hours	168-hours	720-hours
3	2012/4/27 16:00	0.4	1.1	1.1	1.1	1.1	1.5	60.1
4	2012/4/27 17:00	0.2	1.3	1.3	1.3	1.3	1.7	60.3
5	2012/4/27 18:00	0.2	1.5	1.5	1.5	1.5	1.9	60.5
6	2012/4/27 19:00	1.0	2.5	2.5	2.5	2.5	2.8	61.4
7	2012/4/27 20:00	1.6	4.0	4.1	4.1	4.1	4.4	63.0
8	2012/4/27 21:00	2.0	5.3	6.0	6.0	6.0	6.4	65.0
9	2012/4/27 22:00	0.0	4.9	6.0	6.0	6.0	6.4	65.0
10	2012/4/27 23:00	0.0	4.7	6.0	6.0	6.0	6.4	65.0
11	2012/4/28 0:00	0.0	4.5	6.0	6.0	6.0	6.4	65.0
12	2012/4/28 1:00	0.0	3.6	6.0	6.0	6.0	6.4	65.0
13	2012/4/28 2:00	0.0	2.0	6.0	6.0	6.0	6.4	65.0
14	2012/4/28 3:00	0.0	0.0	6.1	6.1	6.1	6.4	65.0
15	2012/4/28 4:00	0.0	0.1	6.1	6.1	6.1	6.5	65.1
16	2012/4/28 5:00	0.0	0.1	6.1	6.1	6.1	6.5	65.1
17	2012/4/28 6:00	0.0	0.1	6.1	6.1	6.1	6.5	65.1
18	2012/4/28 7:00	0.0	0.1	6.1	6.1	6.1	6.4	65.1
19	2012/4/28 8:00	0.0	0.1	6.1	6.1	6.1	6.4	65.1
20	2012/4/28 9:00	0.0	0.1	6.1	6.1	6.1	6.4	65.1
21	2012/4/28 10:00	0.0	0.0	6.1	6.1	6.1	6.4	65.1
22	2012/4/28 11:00	0.0	0.0	6.1	6.1	6.1	6.4	65.1
23	2012/4/28 12:00	0.0	0.0	6.1	6.1	6.1	6.4	65.1
24	2012/4/28 13:00	0.0	0.0	6.1	6.1	6.1	6.4	65.1
25	2012/4/28 14:00	0.0	0.0	6.0	6.1	6.1	6.4	65.1
26	2012/4/28 15:00	0.0	0.0	5.4	6.1	6.1	6.4	65.1
27	2012/4/28 16:00	0.0	0.0	5.0	6.1	6.1	6.4	65.1
28	2012/4/28 17:00	0.0	0.0	4.8	6.1	6.1	6.4	65.1
29	2012/4/28 18:00	0.0	0.0	4.6	6.1	6.1	6.4	65.1
30	2012/4/28 19:00	0.0	0.0	3.7	6.1	6.1	6.4	65.1
31	2012/4/28 20:00	0.0	0.0	2.0	6.1	6.1	6.4	65.1
32	2012/4/28 21:00	0.0	0.0	0.1	6.1	6.1	6.4	65.1
33	2012/4/28 22:00	0.0	0.0	0.1	6.1	6.1	6.4	65.1
34	2012/4/28 23:00	0.0	0.0	0.1	6.1	6.1	6.4	65.1
35	2012/4/29 0:00	0.0	0.0	0.1	6.1	6.1	6.4	65.1
36	2012/4/29 1:00	0.0	0.0	0.1	6.1	6.1	6.4	65.1

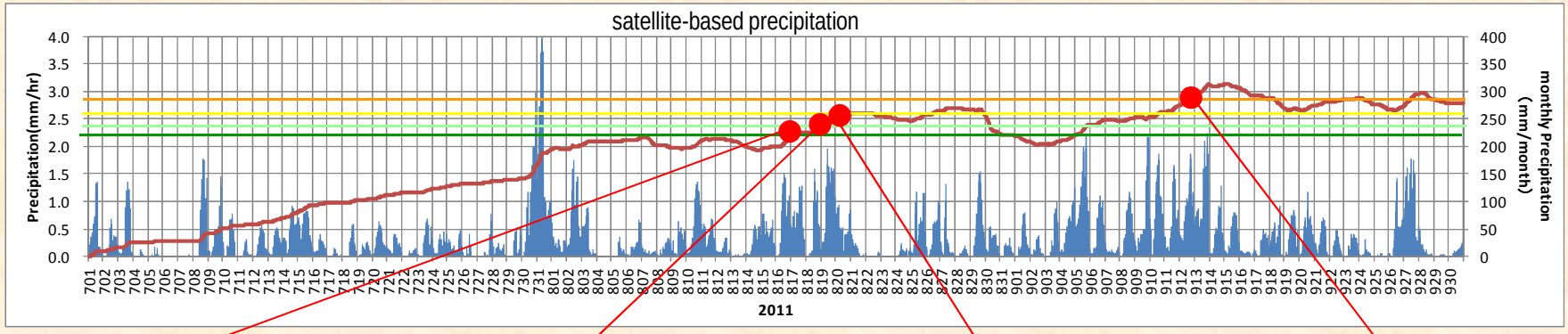
Select start and end date, and click on the ”Download” button!

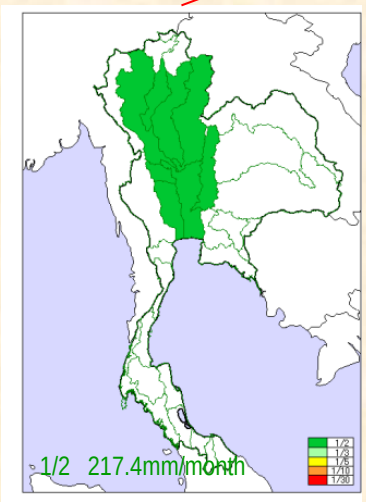
Satellite-based precipitation data (csv file) is downloaded.

Click ！

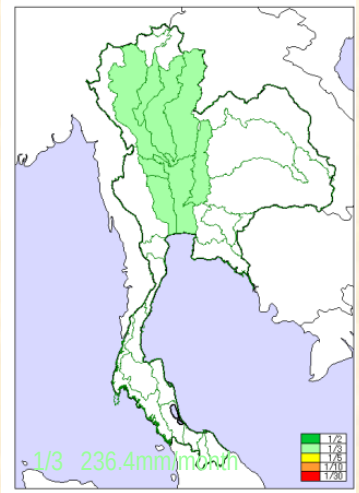
Long-term tend of precipitation retrieved from the System

Retrieved monthly satellite-based precipitation from July to September, 2011

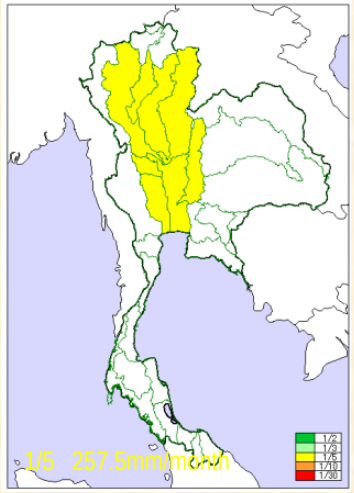




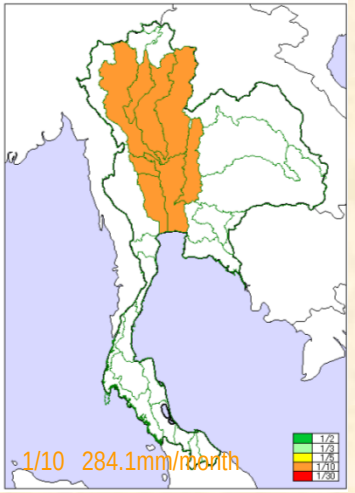
8/17 5:00
Monthly precipitation exceeded 2-year return period.



8/19 9:00
Monthly precipitation exceeded 3-year return period.



8/20 21:00
Monthly precipitation exceeded 5-year return period.



9/12 17:00
Monthly precipitation exceeded 10-year return period.

Satellite-based monthly precipitation exceeded 2-year return period in the mid-August, and 10-year return period in the mid-September.

5. Flood in the Yom River, September 2012

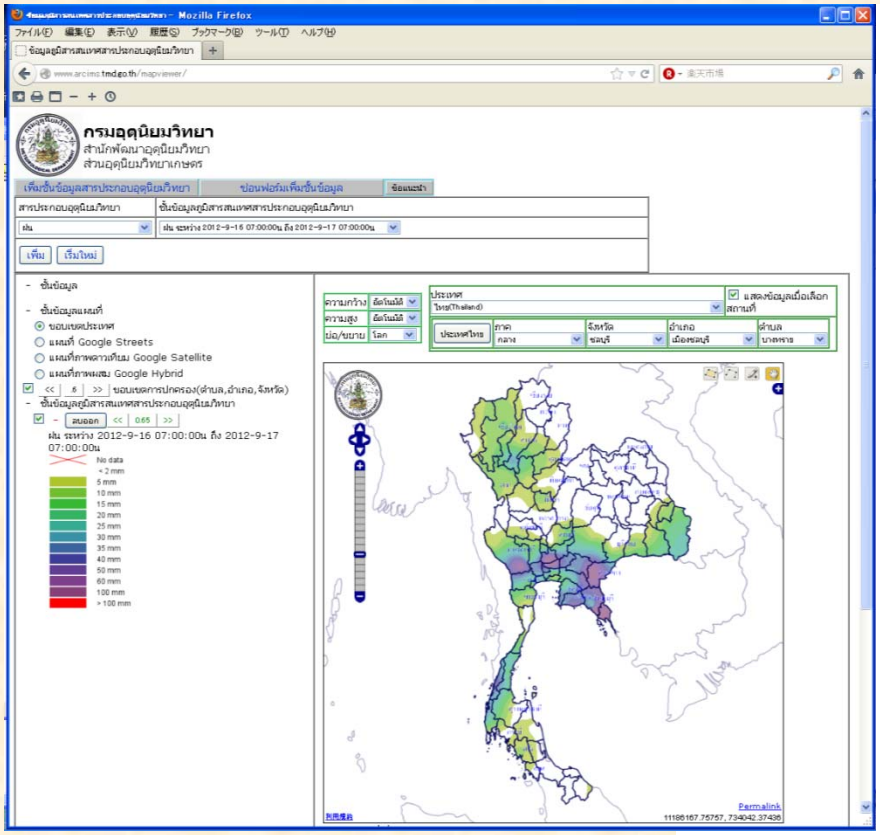
- ***Passing low-pressure brought about flash flood in Sukhothai on September 8, 2012.***
- ***Dyke-break of the Yom River occurred due to over-toping of floodwater on September 10, 2012, which resulted inundation of as many as 1 meter depth. (flood discharge : 1,500m3/s)***
- ***4 people was dead, and over 15,000 were affected. Total damage was estimated at least Bt 30 million.***
- ***However, this flood was "nothing out of ordinary", and breached barrier was "in need of repair", but not yet implemented.***

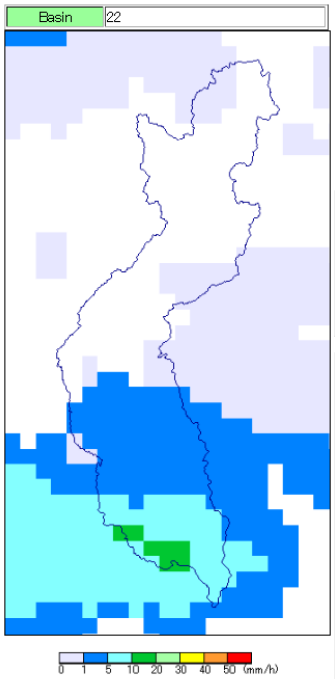
Flood situation in the Yom River

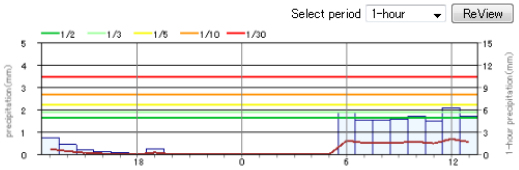
Source: TR weekly website

Precipitation data in the Yom River basin

Precipitation data in the Yom River basin can be acquired both from the Thai Meteorological Department (TMD) and from GSMaP.







period precipitation(mm)

preiod	1-hour	6-hours	24-hours	48-hours	72-hours	168-hours	720-hours
1/2	4.9	22.1	41.5	60.3	69.7	95.4	241.6
1/3	5.7	25.6	50.1	72.3	84.1	107.6	262.9
1/5	6.7	29.2	60.0	85.8	100.2	121.0	283.3
1/10	8.1	33.3	73.2	103.0	120.1	137.8	304.9
1/30	10.4	38.6	94.6	129.4	150.0	162.7	330.5

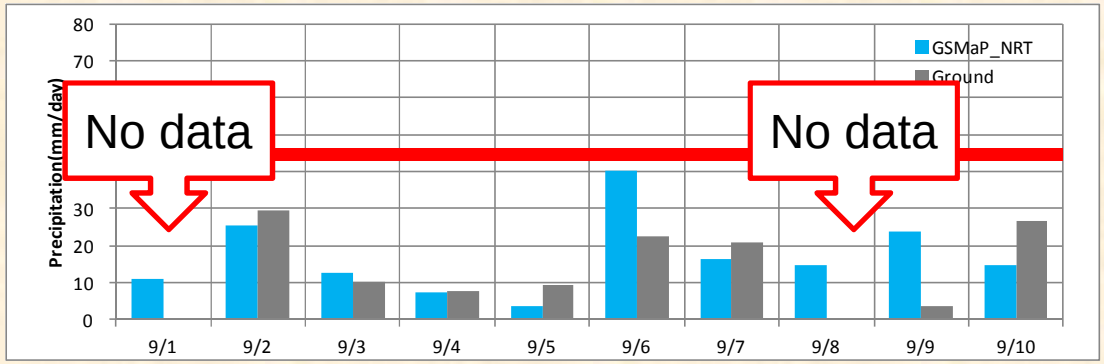
Basin average precipitation(mm)

date	1-hour	6-hours	24-hours	48-hours	72-hours	168-hours	720-hours
2012/09/10 13:00	1.7	10.1	14.9	49.3	60.6	122.4	262.0
2012/09/10 12:00	2.1	10.0	14.0	47.9	61.6	121.0	260.4
2012/09/10 11:00	1.5	9.8	12.6	46.2	62.1	119.3	258.5
2012/09/10 10:00	1.7	8.3	11.9	44.9	62.0	118.0	257.2
2012/09/10 09:00	1.6	6.6	10.5	44.7	60.8	116.6	255.6
2012/09/10 08:00	1.6	5.0	11.4	44.2	59.4	115.3	254.1
2012/09/10 07:00	1.6	3.5	12.7	43.2	57.9	113.8	252.6
2012/09/10 06:00	1.9	1.9	13.9	42.0	56.5	112.3	251.2
2012/09/10 05:00	0.0	0.1	14.5	40.1	54.7	110.5	249.3
2012/09/10 04:00	0.0	0.1	16.5	40.1	54.9	110.8	249.3
2012/09/10 03:00	0.0	0.1	18.0	40.1	54.9	111.3	249.3
2012/09/10 02:00	0.0	0.1	19.2	40.0	55.0	111.9	249.3
2012/09/10 01:00	0.0	0.2	19.8	40.0	55.2	112.9	249.3
2012/09/10 00:00	0.0	0.4	22.1	40.0	55.4	114.4	249.3
2012/09/09 23:00	0.0	0.4	25.1	40.1	55.6	117.9	249.3
2012/09/09 22:00	0.0	0.5	28.2	40.2	56.0	121.3	249.3
2012/09/09 21:00	0.0	0.6	30.3	40.1	56.2	124.9	249.4
2012/09/09 20:00	0.0	0.8	32.1	41.0	56.5	128.9	249.5
2012/09/09 19:00	0.3	1.2	33.4	41.5	56.9	132.9	249.5
2012/09/09 18:00	0.0	1.6	34.0	41.6	56.9	135.5	249.3
2012/09/09 17:00	0.1	2.3	34.6	41.8	57.4	136.0	249.5
2012/09/09 16:00	0.1	3.0	34.8	42.3	60.9	136.2	249.6
2012/09/09 15:00	0.2	3.3	34.8	43.0	65.9	136.6	249.6
2012/09/09 14:00	0.5	5.5	34.7	43.7	71.3	137.0	249.4
2012/09/09 13:00	0.7	7.9	34.3	45.6	77.4	137.3	249.1

1/2 1/3 1/5 1/10 1/30

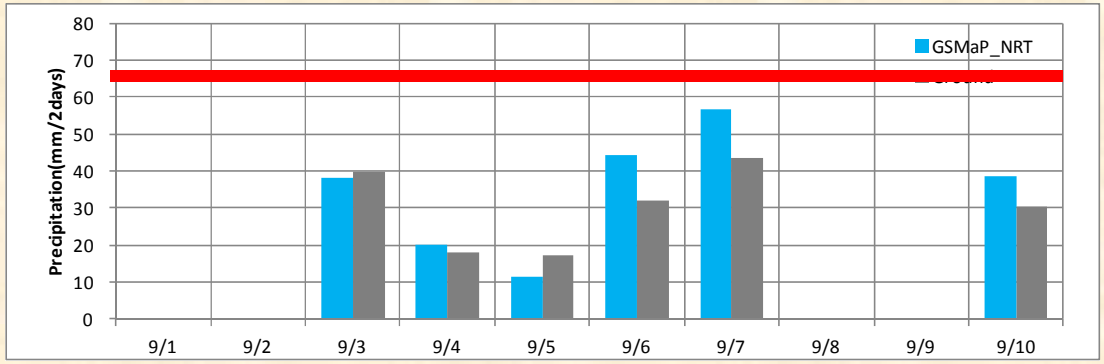
download

Comparison of the ground observation data and satellite monitoring precipitation data



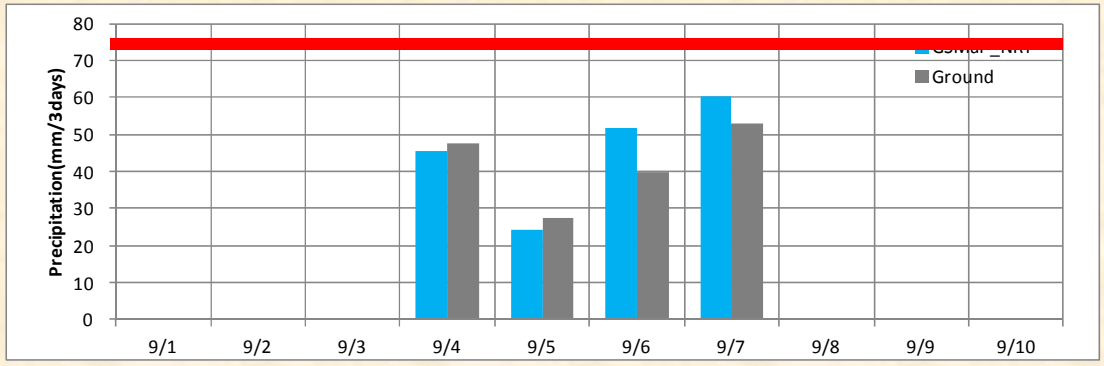
1 day (=24 hours) precipitation

* 1/2 : 41.5mm



2 days (=48 hours) precipitation

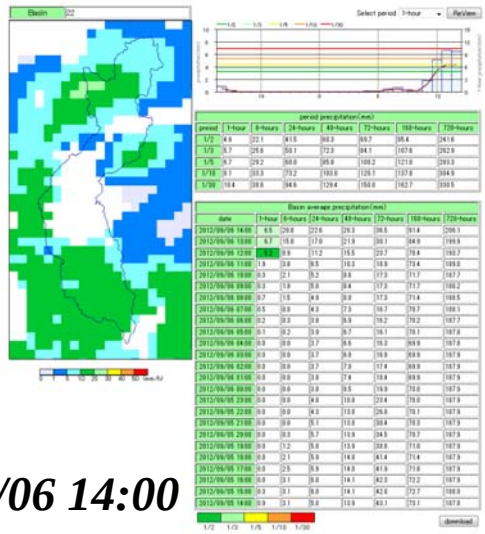
* 1/2 : 60.3mm



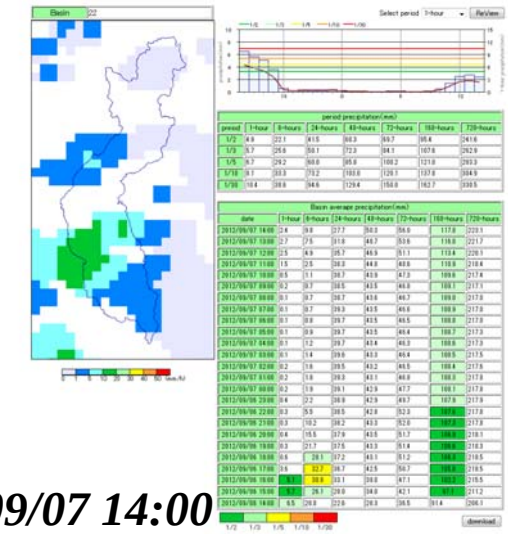
3 days (=72 hours) precipitation

* 1/2 : 69.7mm

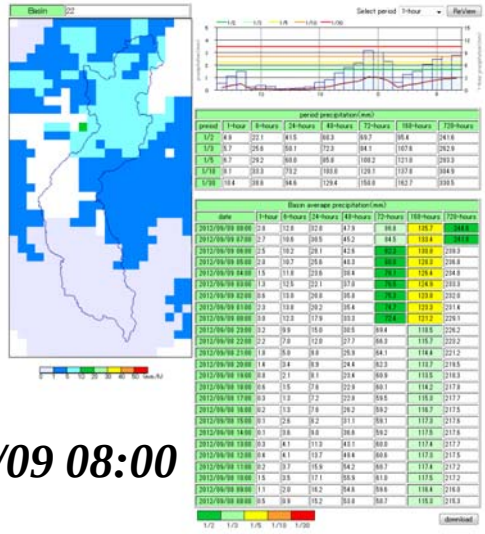
Retrieved precipitation data from the System



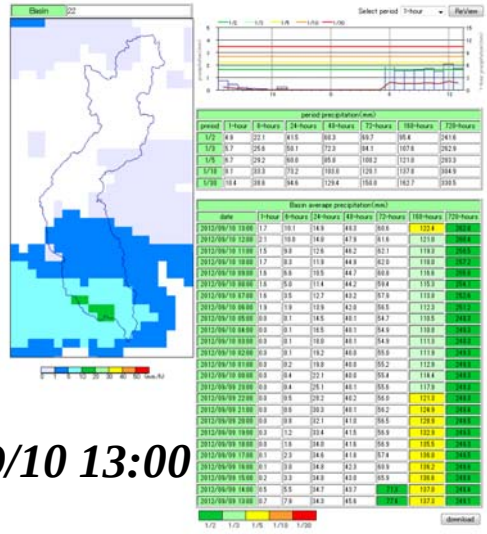
2012/09/06 14:00



2012/09/07 14:00



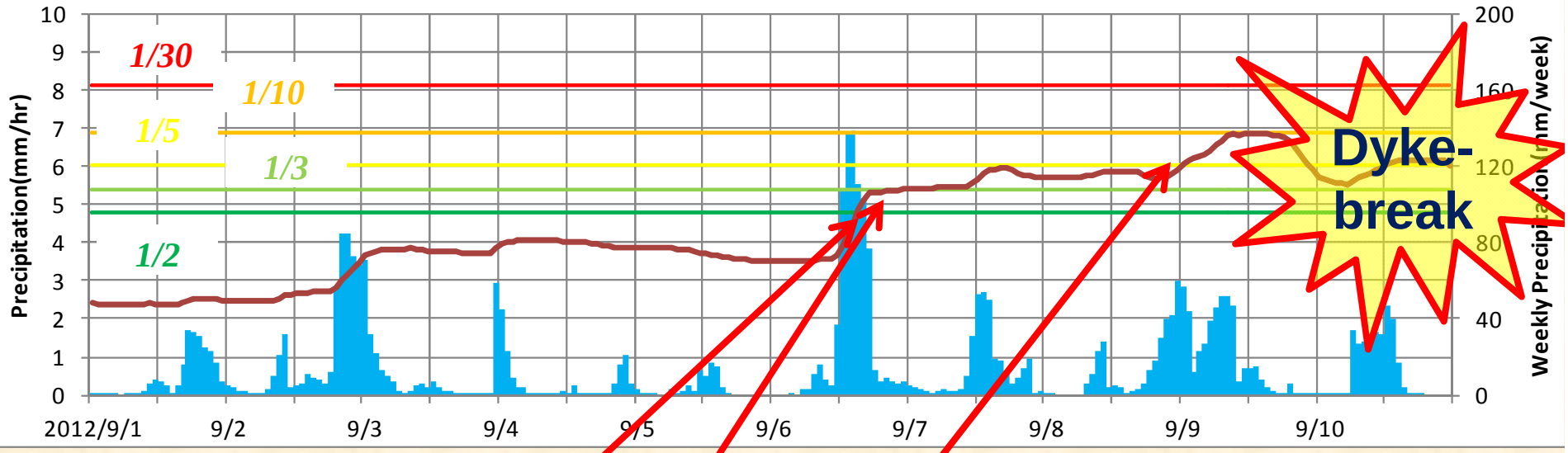
2012/09/09 08:00



2012/09/10 13:00

Before the dyke broke on September 10, the system indicated the long-term precipitation (3-days, 7-days) already reached to the critical level (1/3-1/5).

Satellite-monitoring precipitation in the Yom River basin



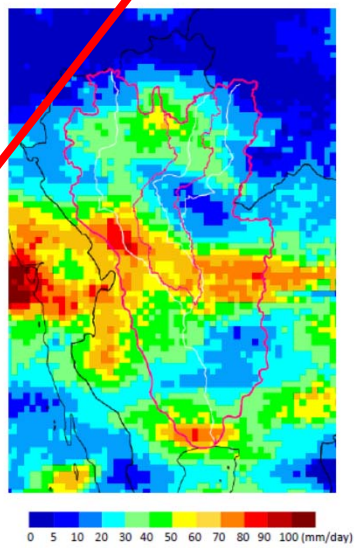
9/6 15:00
Weekly precipitation exceeded 2-year return period.

9/6 22:00
Weekly precipitation exceeded 3-year return period.

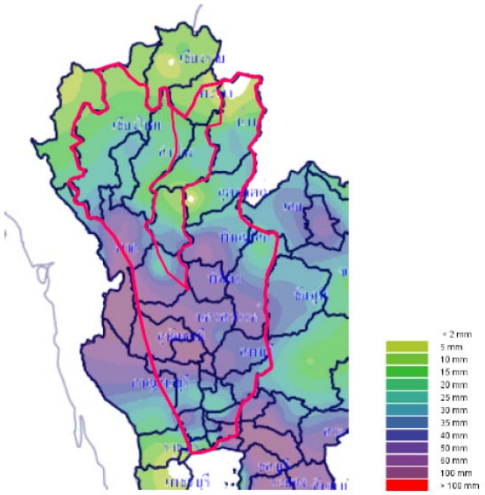
9/9 00:00
Weekly precipitation <u>exceeded 5-year return period</u>, still went up to almost <u>10-year return period</u>.

2012/9/6

Satellite Data/ GSMaP_NRT
Ground Data/ TMD



GSMaP_NRT
40.3 mm/day



Ground
22.6 mm/day

6. Findings from the comparison

- ***Although precipitation of 1-3 days was relatively small (less than 1/ 2 years), precipitation trend/ pattern was found quite similar. And trend/pattern of 3-days precipitation was much more similar.***
- ***While ground observation system is surely essential for adequate flood forecasting and warning, satellite monitoring precipitation can supplement & support flood management where ground observation network is scarce.***
- ***The System retrieved that the weekly-precipitation exceeded 1/5 years on September 9, which was just one day before the dyke actually broke.***
- ***This means the flood disaster could have been foreseen by checking the satellite precipitation from the System.***

6. Conclusion

- ***Ground observation need lots of time and huge cost for installation, therefore satellite-monitoring precipitation can supplement and support flood management (warning and forecasting).***
- ***GFAS can be applicable with good accuracy to relatively large-scale river basin and for long-term prediction.***
- ***Still they need to develop and improve, so we want to invite more countries/ organizations to participate in our activities.***
- ***Recent progress includes the development of Satellite-Based Precipitation Data Delivery System for Thailand.***
- ***By using this System, Chao Phraya flood in 2011 and Yom River flood in 2012 can be retrieved, which suggests the System provide useful information for the flood management before actual flood disaster occurs.***

Thank you very much for your attention

Please contact to 2bu01@idi.or.jp:

IFNet: http://www.internationalfloodnetwork.org

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