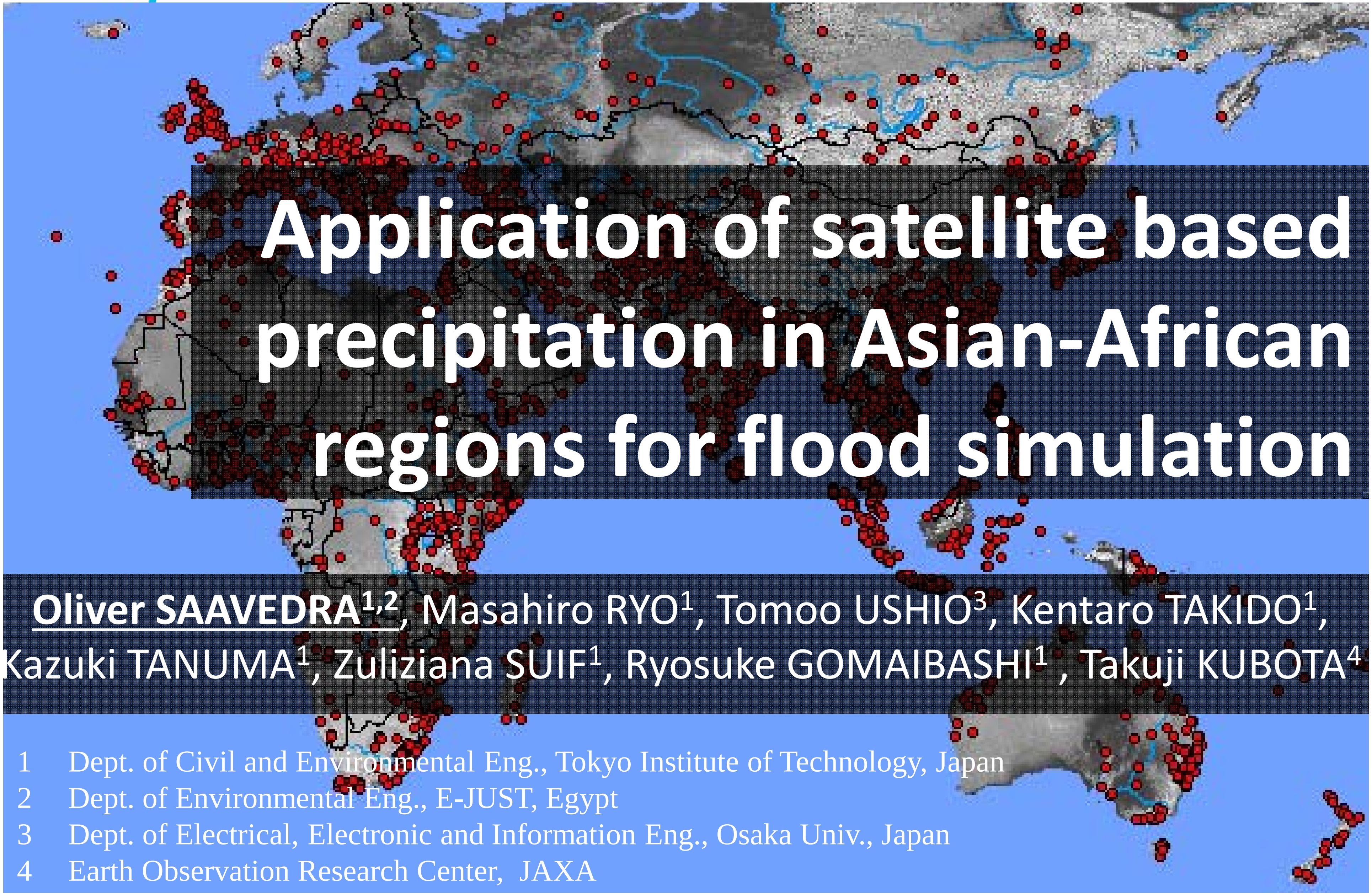
2014.01.16



Application of satellite based precipitation in Asian-African regions for flood simulation

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1 Dept. of Civil and Environmental Eng., Tokyo Institute of Technology, Japan
2 Dept. of Environmental Eng., E-JUST, Egypt
3 Dept. of Electrical, Electronic and Information Eng., Osaka Univ., Japan
4 Earth Observation Research Center, JAXA

Floods in Asia and Africa


Hue city, Vietnam


El-Arish, Egypt


Bangkok, Thailand


Khartoum, Sudan

Floods in Asia and Africa

Flood prevention

In developed countries

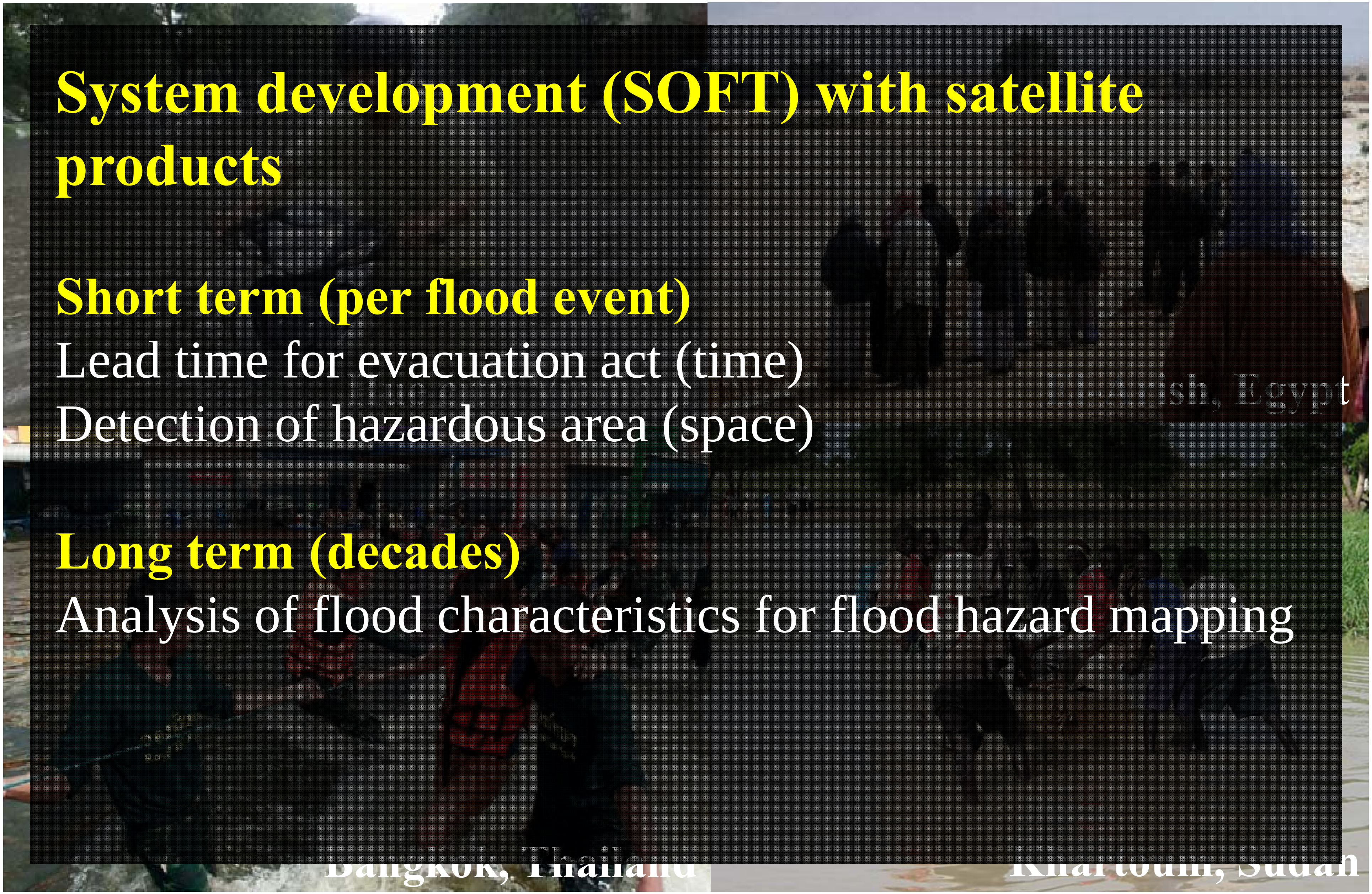
- Dam reservoir/Weir
- Embankment
- Dense rain gauge measurement
- Regional forecast system etc.

In contrast …

In developing countries, such countermeasure facilities (HARD) are still poorly implemented due to monetary limitation.

⇒ Importance of system development (SOFT)

Floods in Asia and Africa



System development (SOFT) with satellite products

Short term (per flood event)

Lead time for evacuation act (time)

Detection of hazardous area (space)

Long term (decades)

Analysis of flood characteristics for flood hazard mapping

Objectives

To investigate the applicability of Satellite Based Precipitation (SBP) in combination with local observation network to improve the spatial and temporal resolution of measurements in Asian and African river basins.

To evaluate SBPs from the hydro-meteorological perspective and applicability for flood management

Strategies

We plan to

1) Evaluate of SBP products at selected basins
2) Suggest different correction methods at basin and local scale for different tempo-spatial scales
3) Apply enhanced dataset as input for a hydrological model and compare simulated river discharge
4) Support flood risk assessment under different scenarios

Applications in Asian region

Japan, Vietnam, Thailand, Mekong

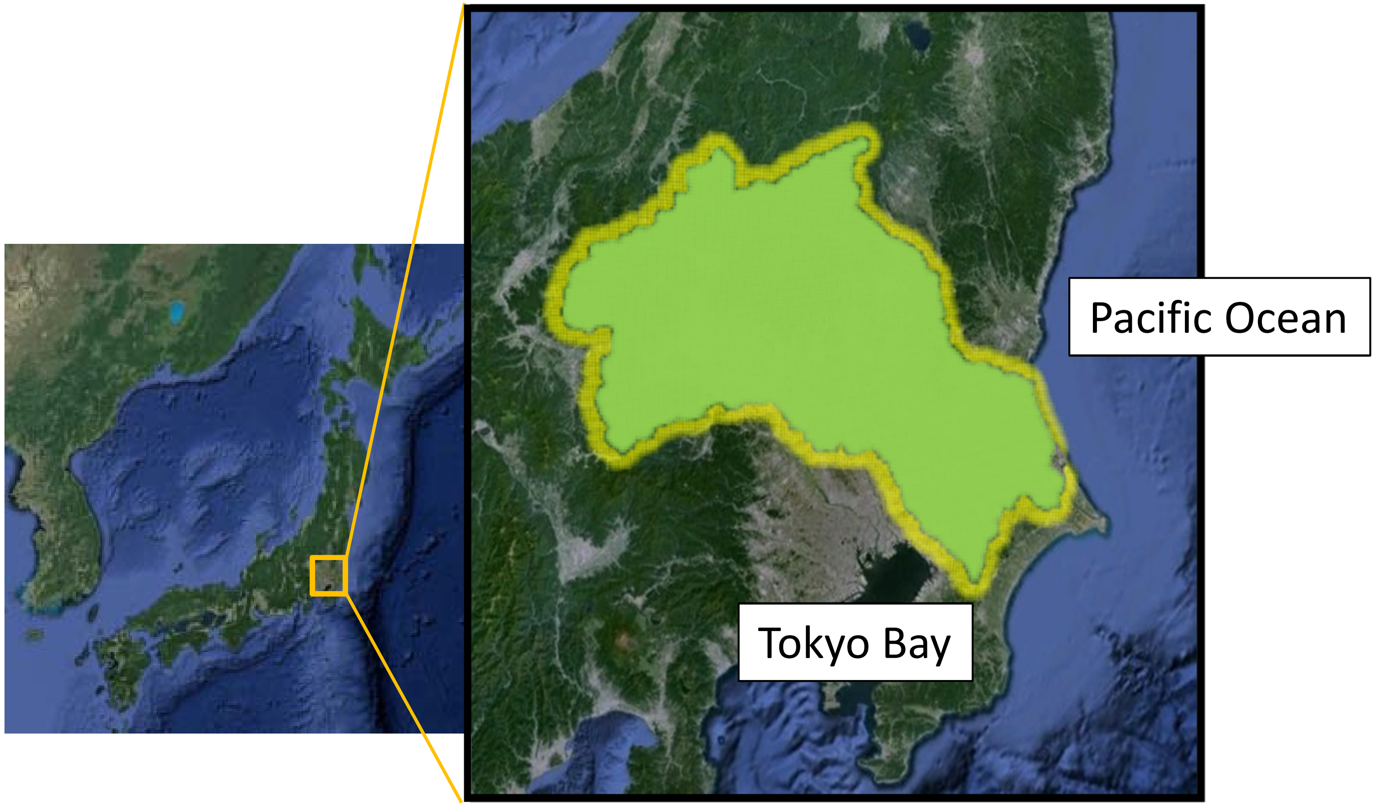
in African region

Nile basin, Sinai peninsula

Test basins in Asia

	Tone in Japan	Huong in Vietnam	Mekong River
Basin size (km^2)	16800	1500	795000
Annual rainfall (mm)	1200	2800	2500
Precipitation Product	GSMap_MVK, GSMap_gauge	GSMap_MVK, GSMap_gauge	GSMap_gauge
Period	2006-2009	2006-2009	2000
Time step	hh, dd, mm	6h, day	dd, mm
Eval. approach	POD, FAR, R, Effect of PMW & IR	POD, FAR, R, RMSE, NSE, Bias	Bias
Qsim with DHM	NA	OK	OK
Temporal downscaling	NY	OK	NY

Tone River Basin, Japan
Target area of evaluation

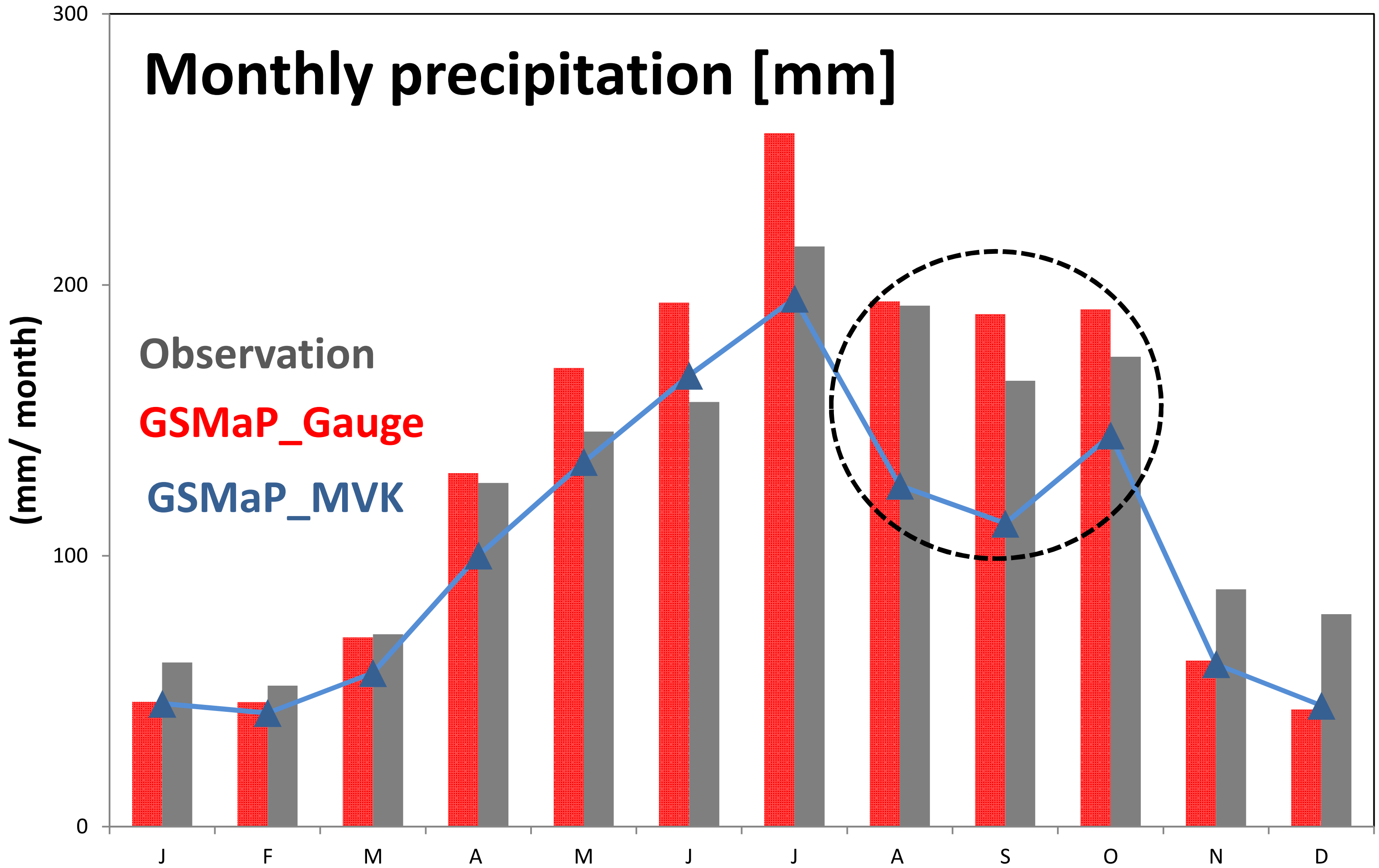


Location of Tone River Basin
(Buffered by 7 km)

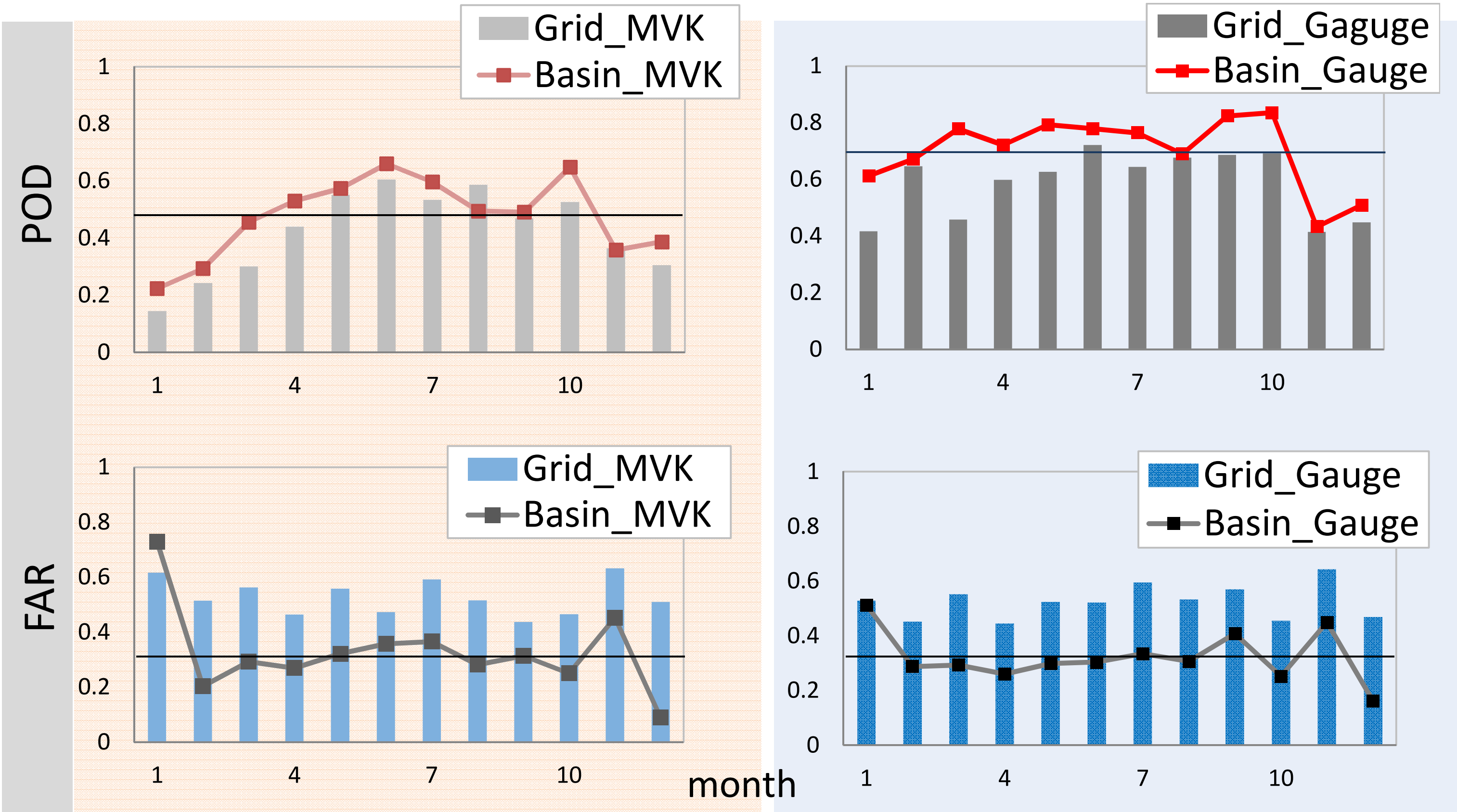
Area = 16830 km^2 (Buffered 20560 km^2)
No. of Obs. Gauges: 78 stations
Annual average prec = 1300 mm

Monthly Precipitation (Tone)

- Overestimation in summer
- Underestimation in winter



Comparison of Average Monthly POD and FAR from 2006-2009

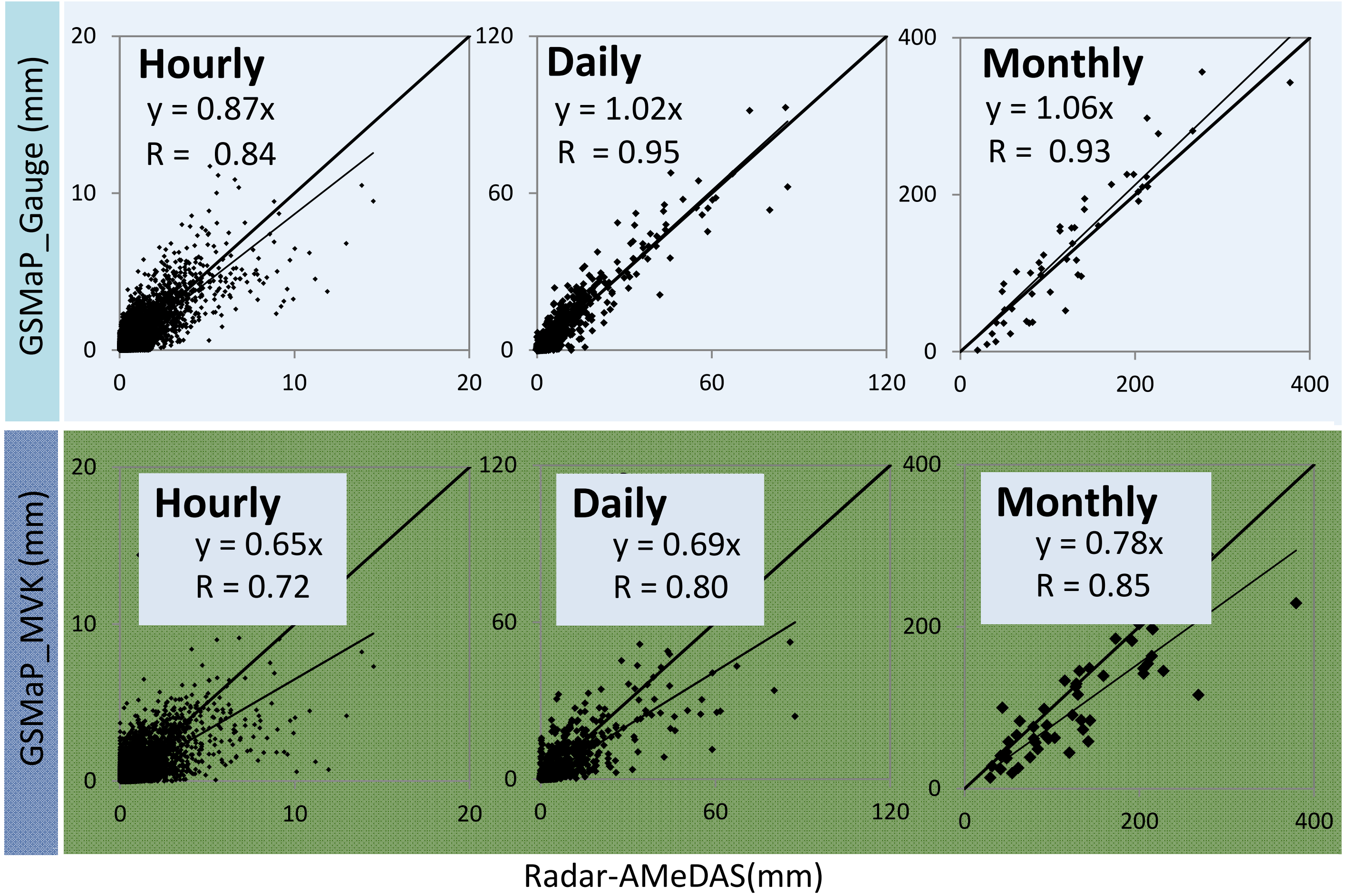


FAR remains relatively stable, but there is an overall improvement on POD.

	MVK	Gauge
POD	0.48	0.70
FAR	0.33	0.32

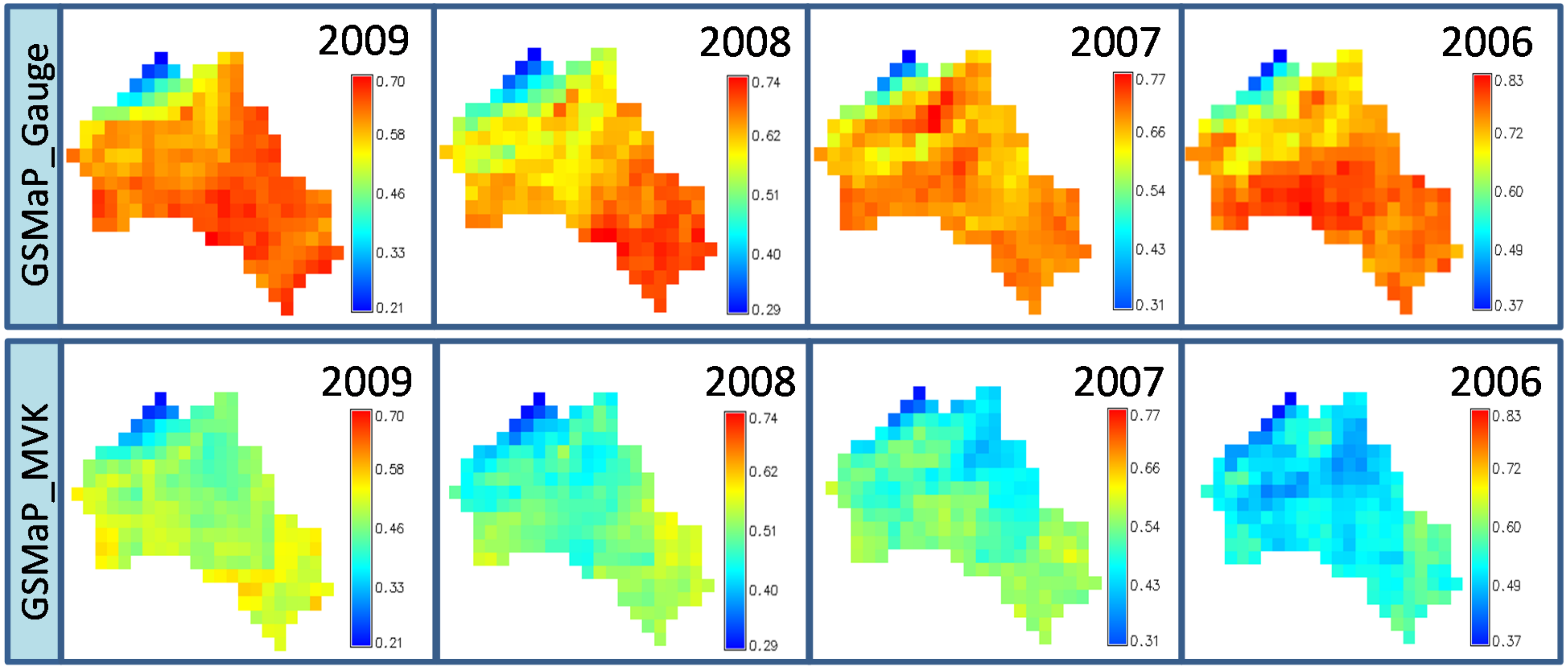
Annual avg. of POD and FAR

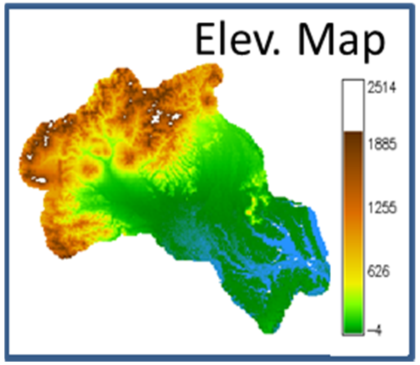
Comparison of Linear Regression in Various Time Scale



Daily Correlation error (R) close to 1 (=0.95)

Spatial distribution of POD

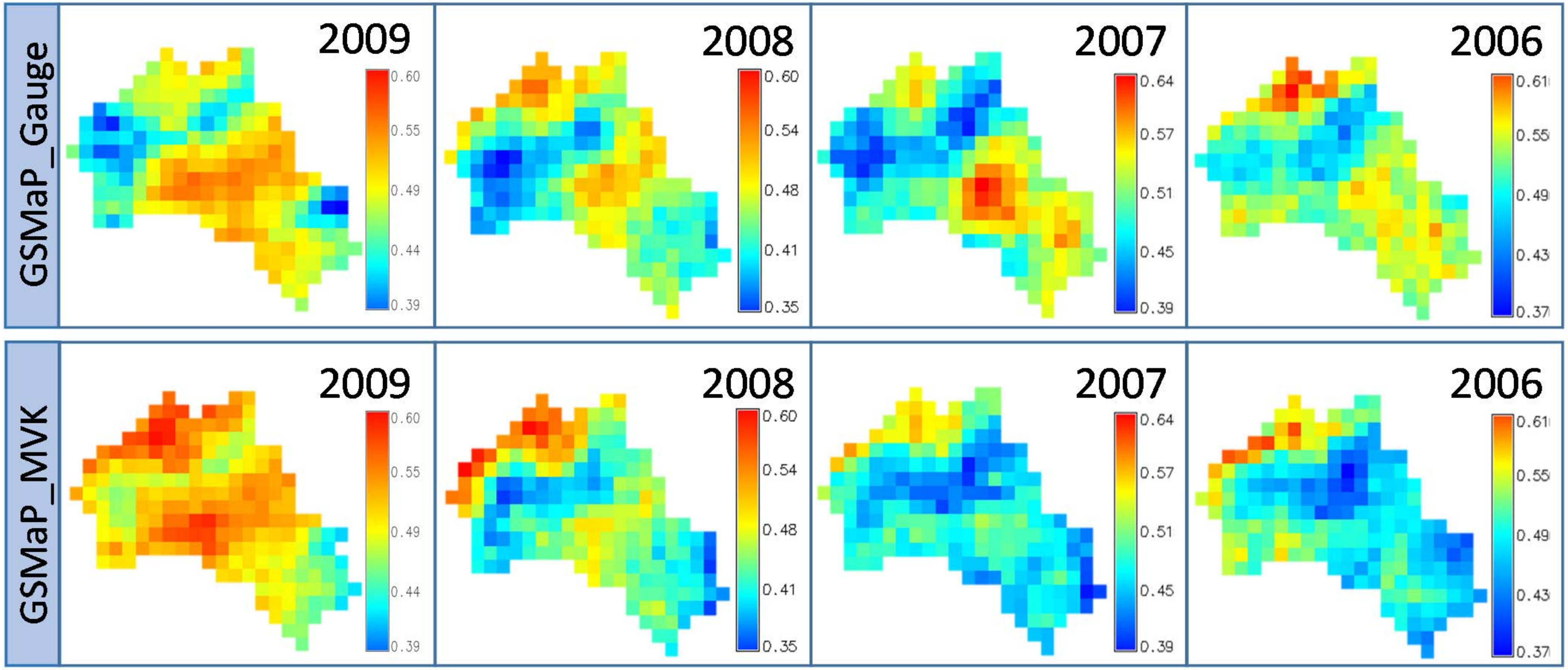




Overall improvement on POD

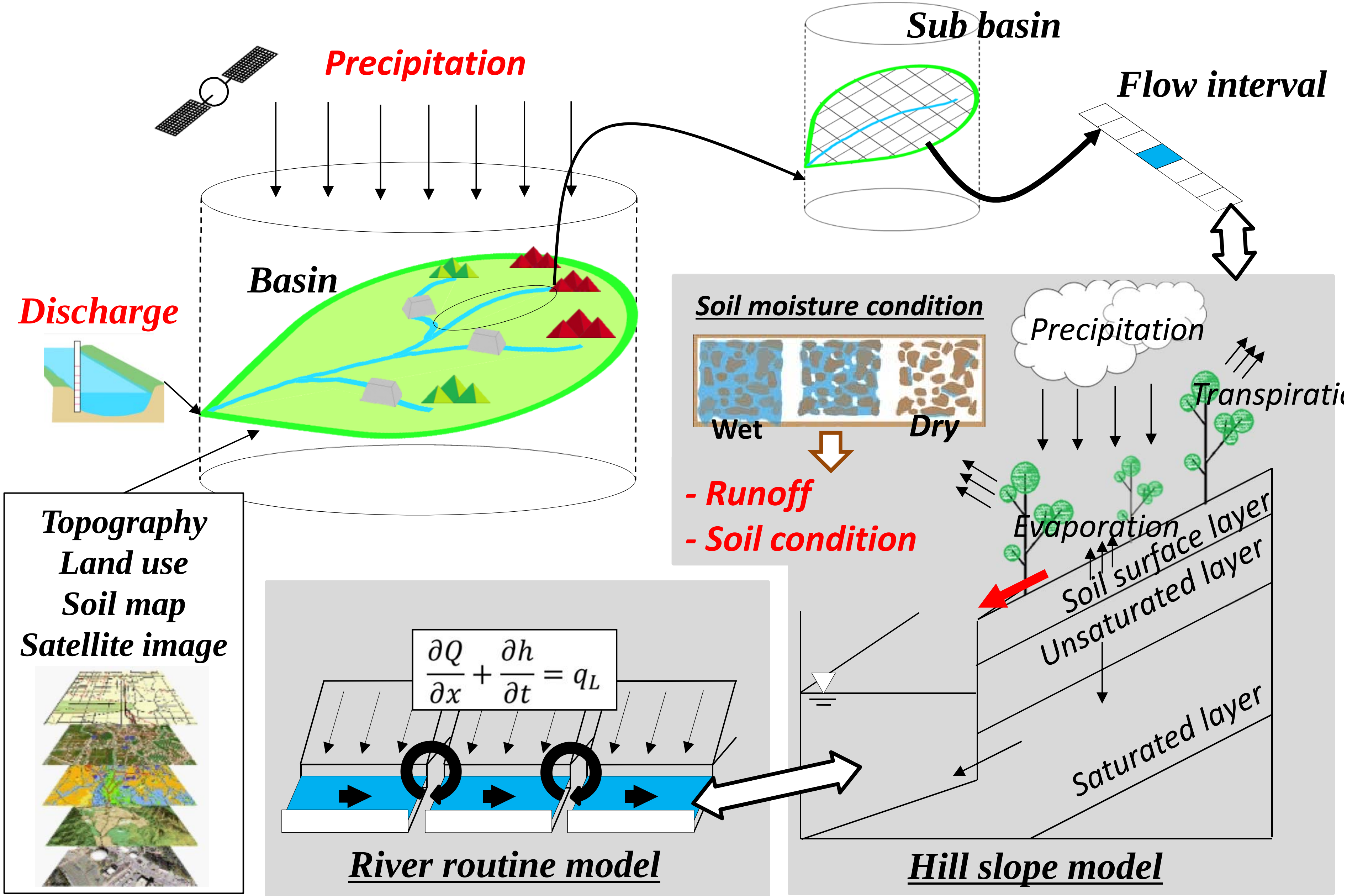
Low POD in the northwest: possibly due to snowfall in western Japan

Spatial distribution of FAR

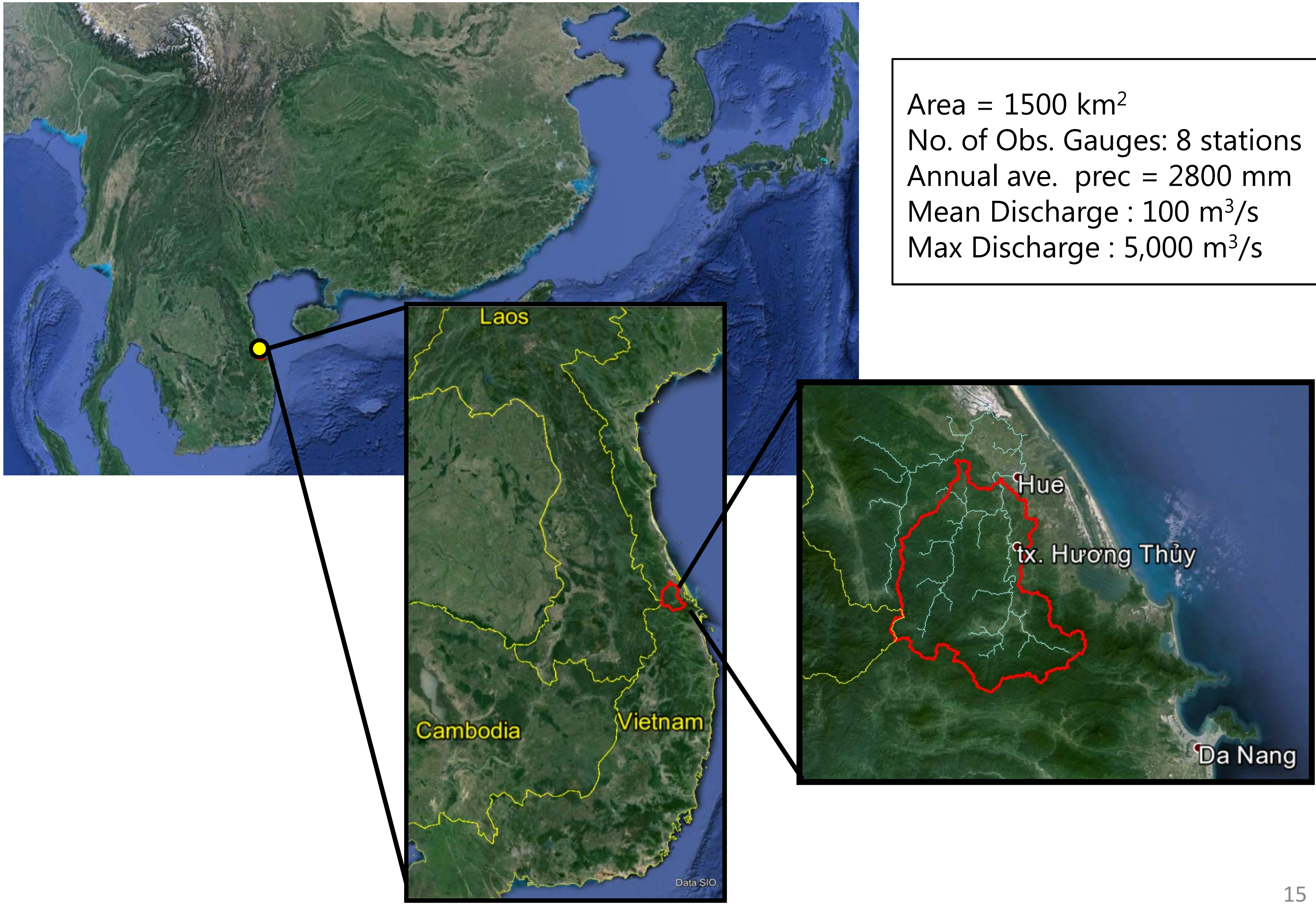


Little difference in comparison of FAR

Distributed Hydrological Model



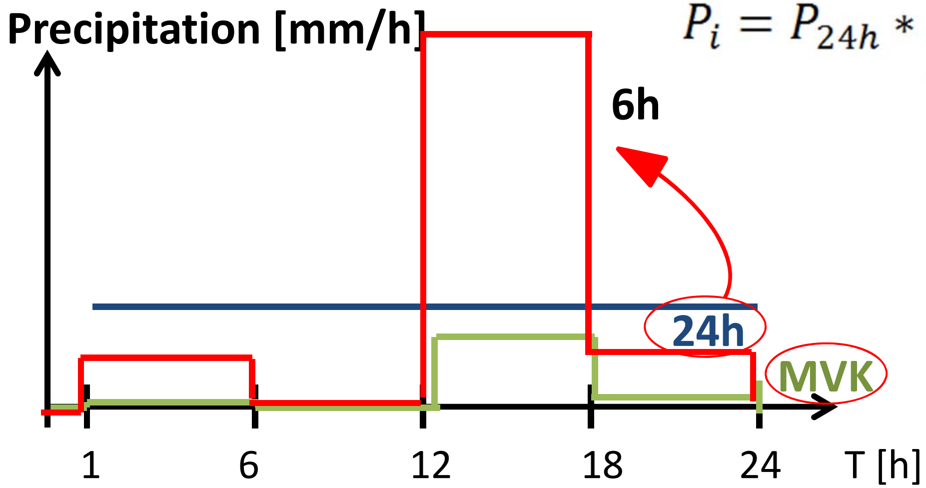
Huong River basin Target area of evaluation



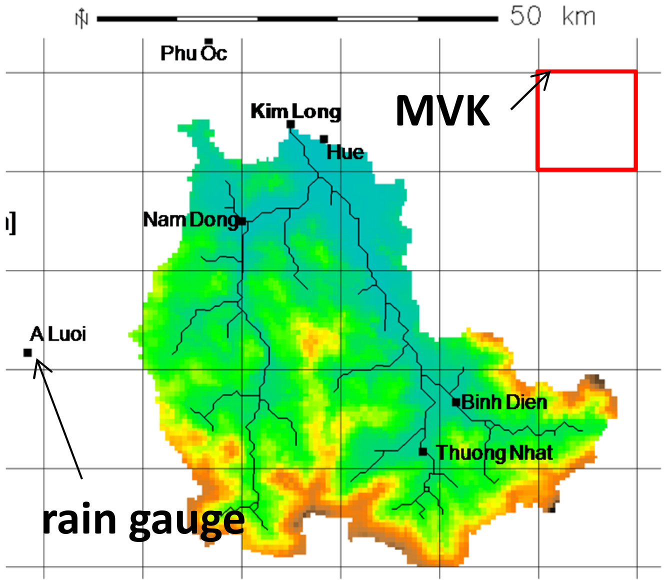
Area = 1500 km^2
No. of Obs. Gauges: 8 stations
Annual ave. prec = 2800 mm
Mean Discharge : 100 m^3/s
Max Discharge : 5,000 m^3/s

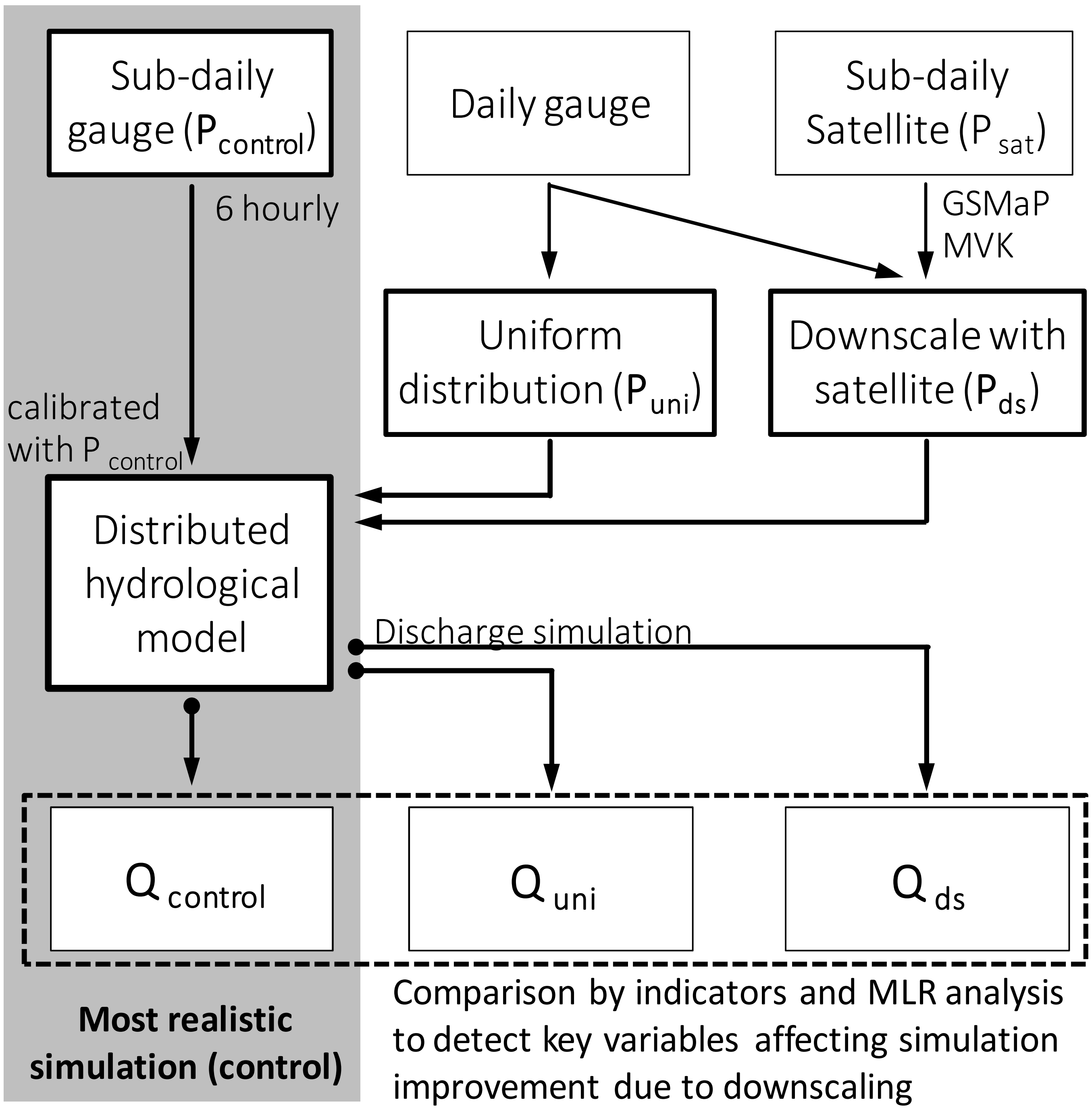
Method for temporal downscaling

Huong



$$P_i = P_{24h} * \frac{MVK_i}{\sum_{i=1}^{4} MVK_i}$$





Sub-daily gauge (P control)
Daily gauge
Sub-daily Satellite (P sat)
6 hourly
GSMaP MVK
Uniform distribution (P uni)
Downscale with satellite (P ds)
calibrated with P control
Distributed hydrological model
Discharge simulation
Q control
Q uni
Q ds
Most realistic simulation (control)
Comparison by indicators and MLR analysis to detect key variables affecting simulation improvement due to downscaling

Simulation results

Huong

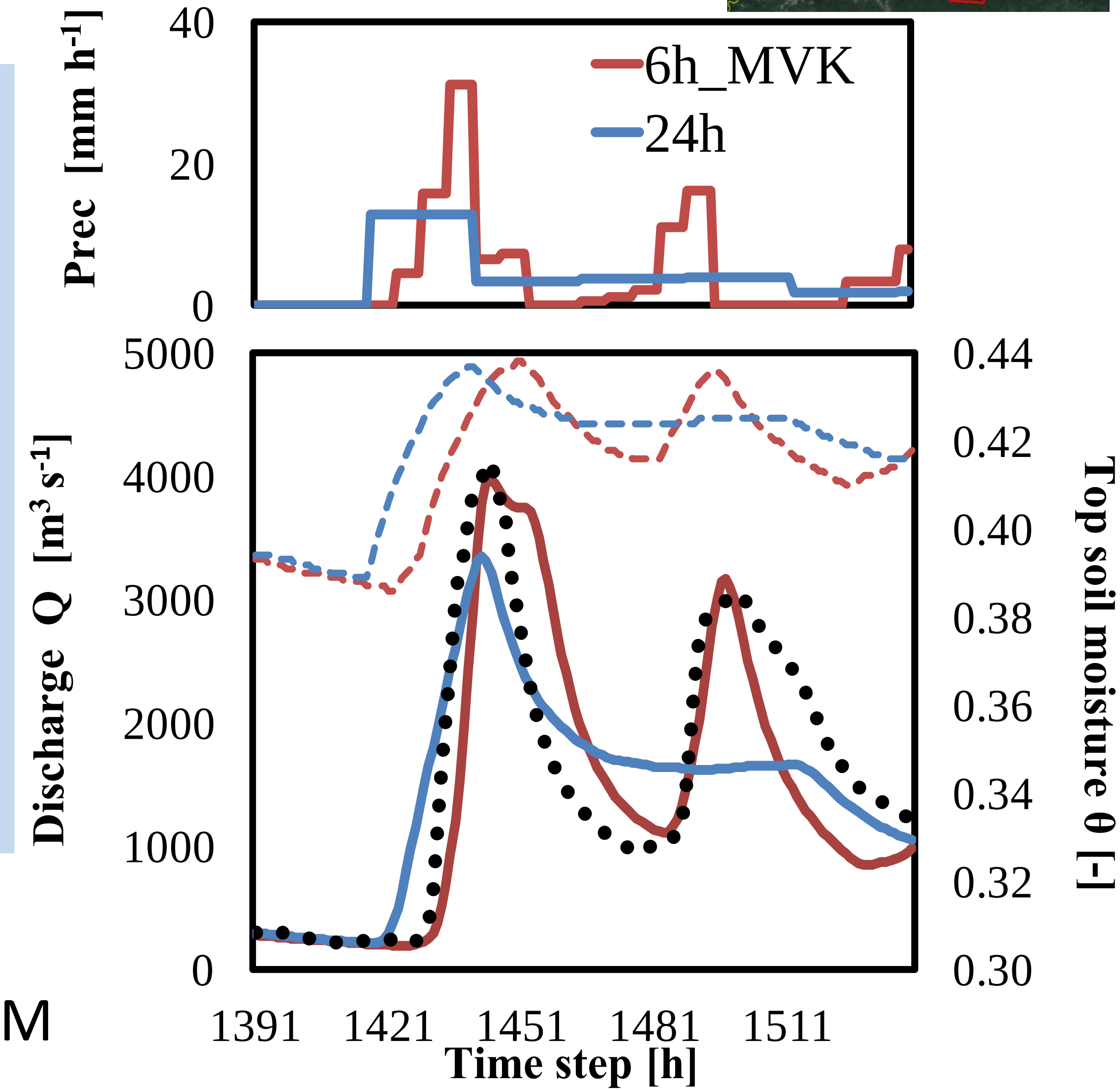
18 flood events were targeted
Evaluation indicator (NSE) showed significant improvement

0.33 → 0.63

improved 14 out of 18 flood cases

How can this method be used?

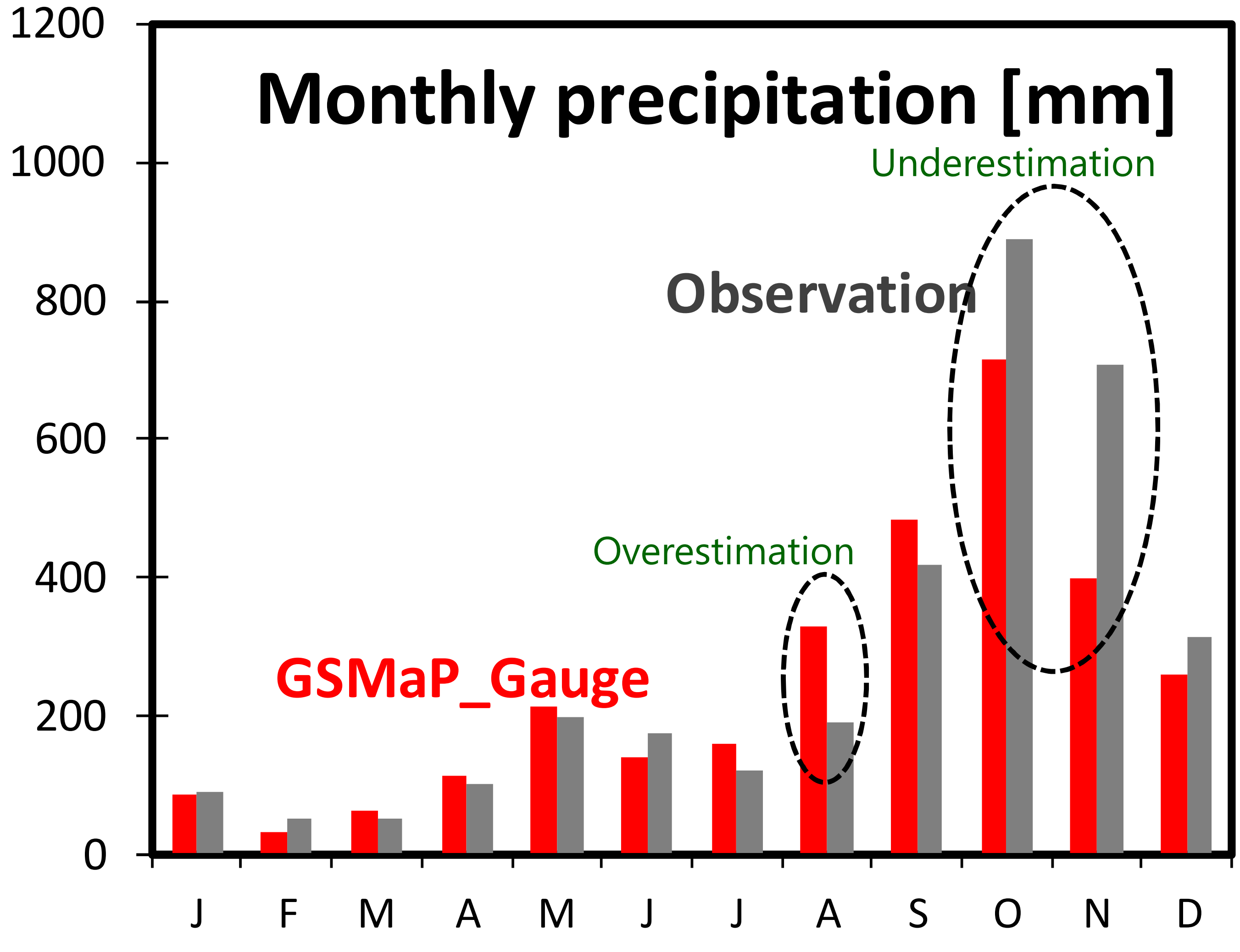
This temporal downscaling can be used at any basins where have low temporal precipitation data, but are affected by flush floods.



Ryo, Saavedra et al 2014, JHM

GSMaP_gauge Monthly precipitation 2000 - 2010

- Overestimation in August
- Underestimation in October and November

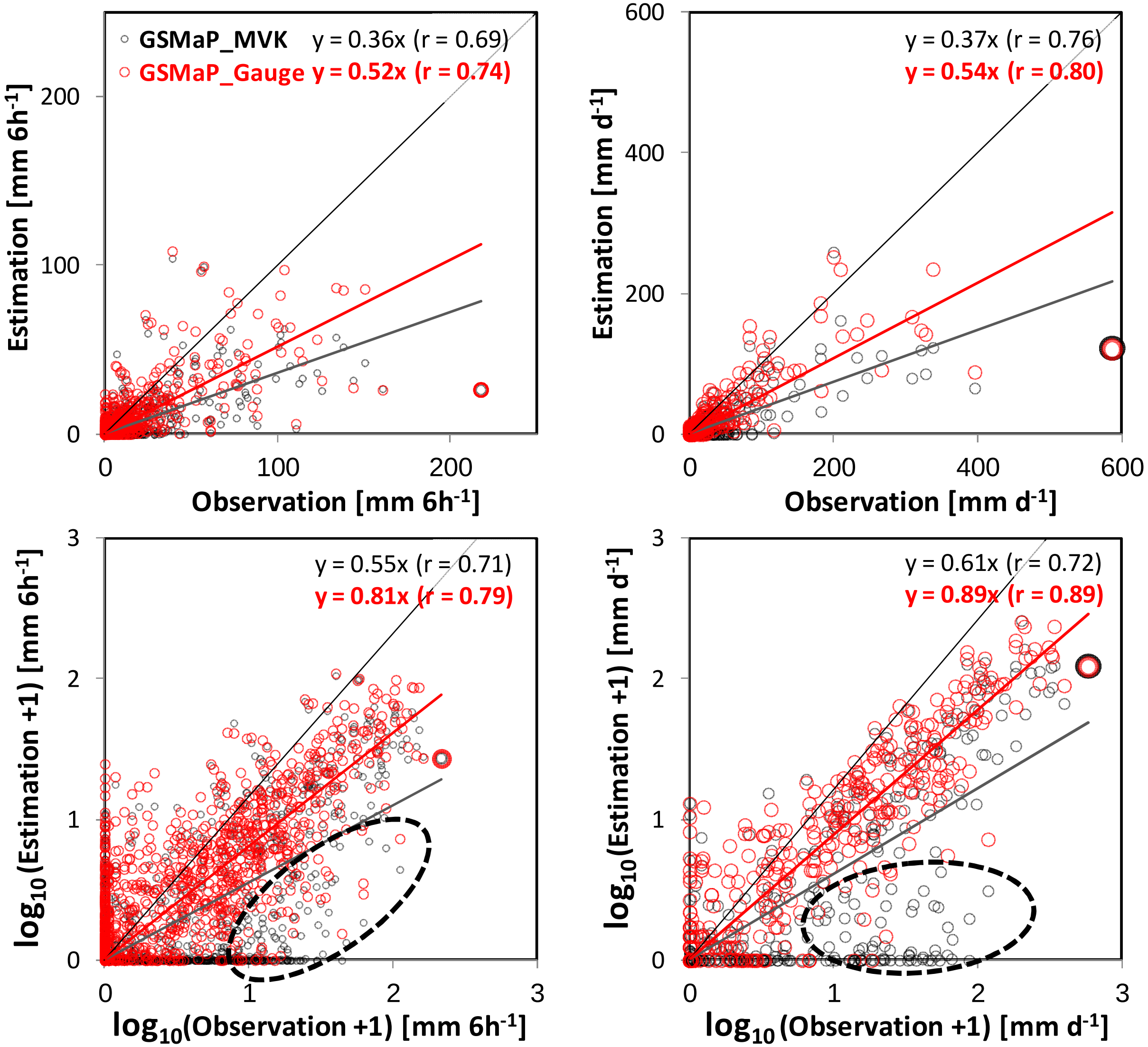


Precipitation 6hourly and daily Sep-Nov in 2006-2009

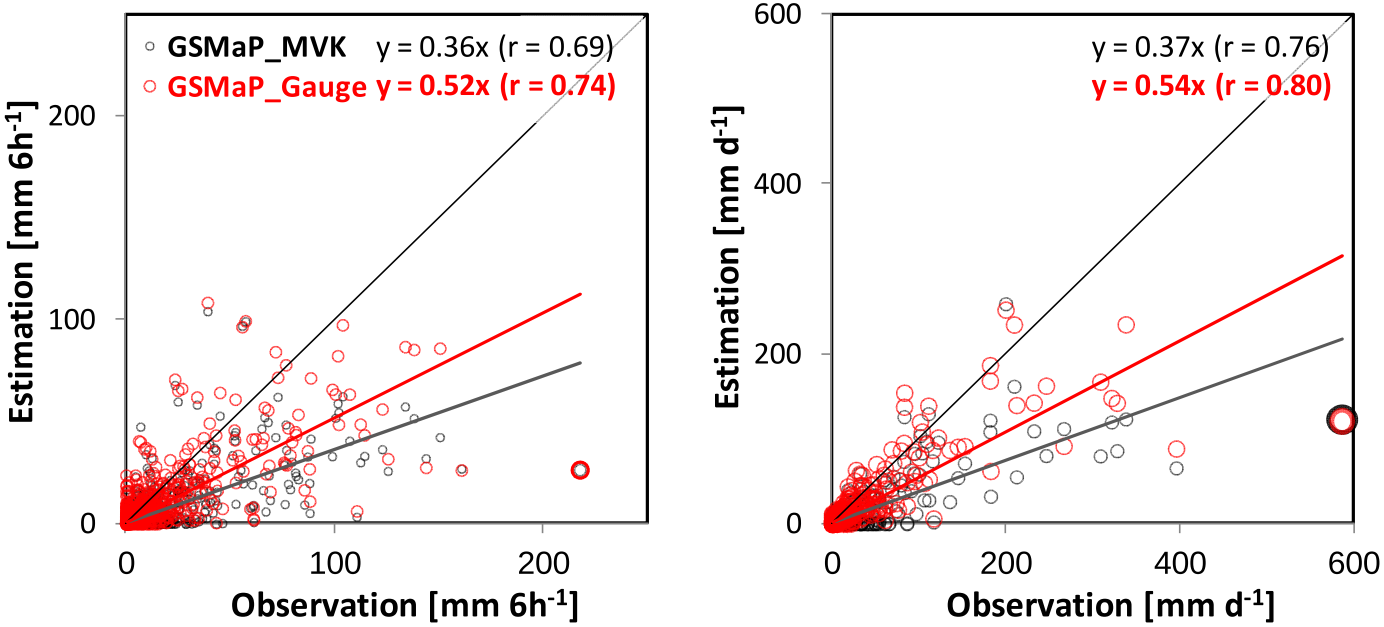
Tendency: underestimation

Accuracy: GSMaP_Gauge > MVK

Log-transformation shows the improvement clearly.



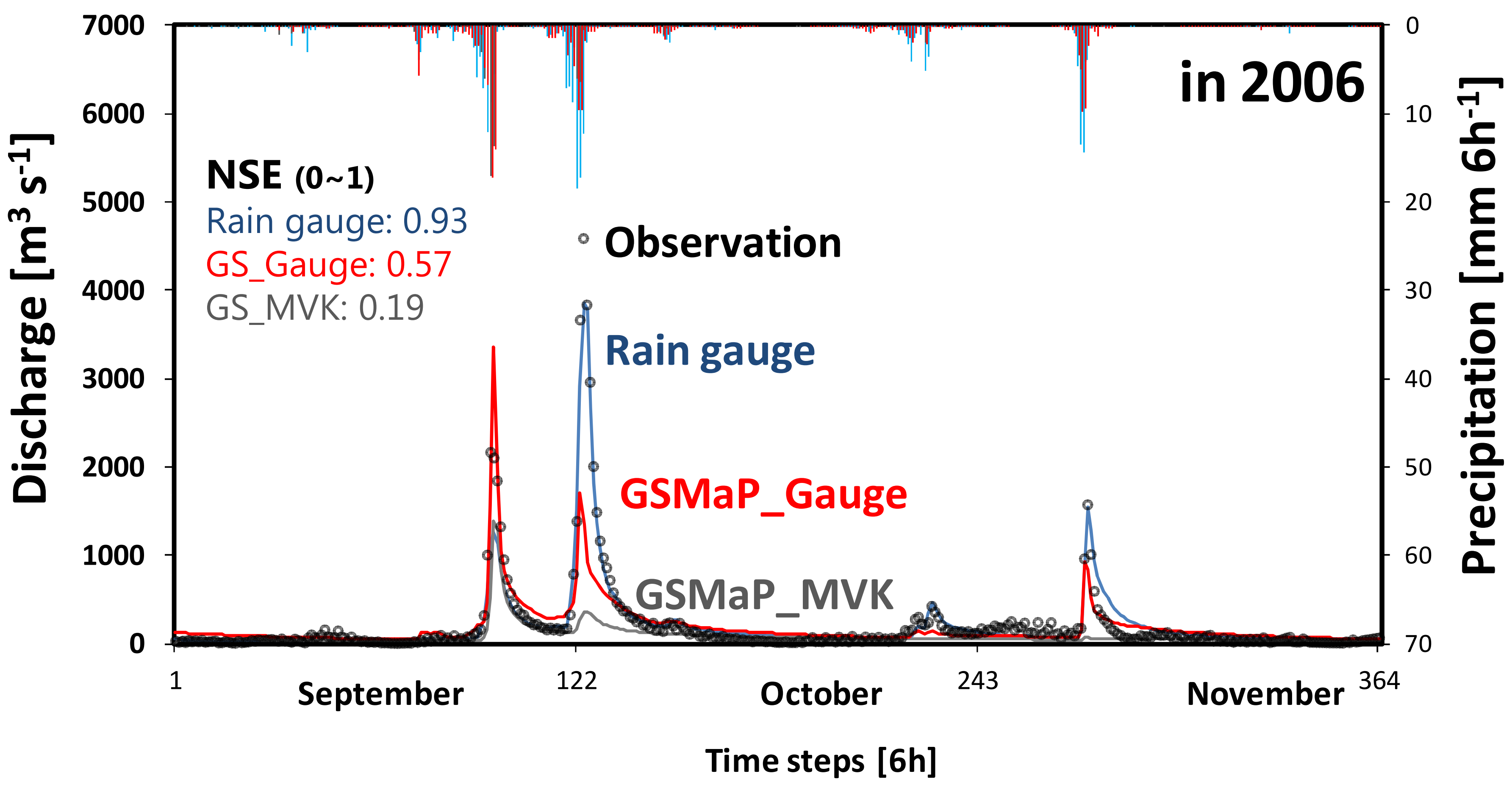
Precipitation evaluation scores



	6 hourly		daily	
	Gauge	MVK	Gauge	MVK
RMSE	12.7	14.6	39.5	47.6
correlation	0.74	0.69	0.80	0.76
Bias	-0.29	-0.58	-0.29	-0.58
POD	0.89	0.53	0.89	0.58
FAR	0.27	0.16	0.10	0.07
TS	0.67	0.48	0.81	0.56

(Threshold amount = 1.0 mm d^{-1})

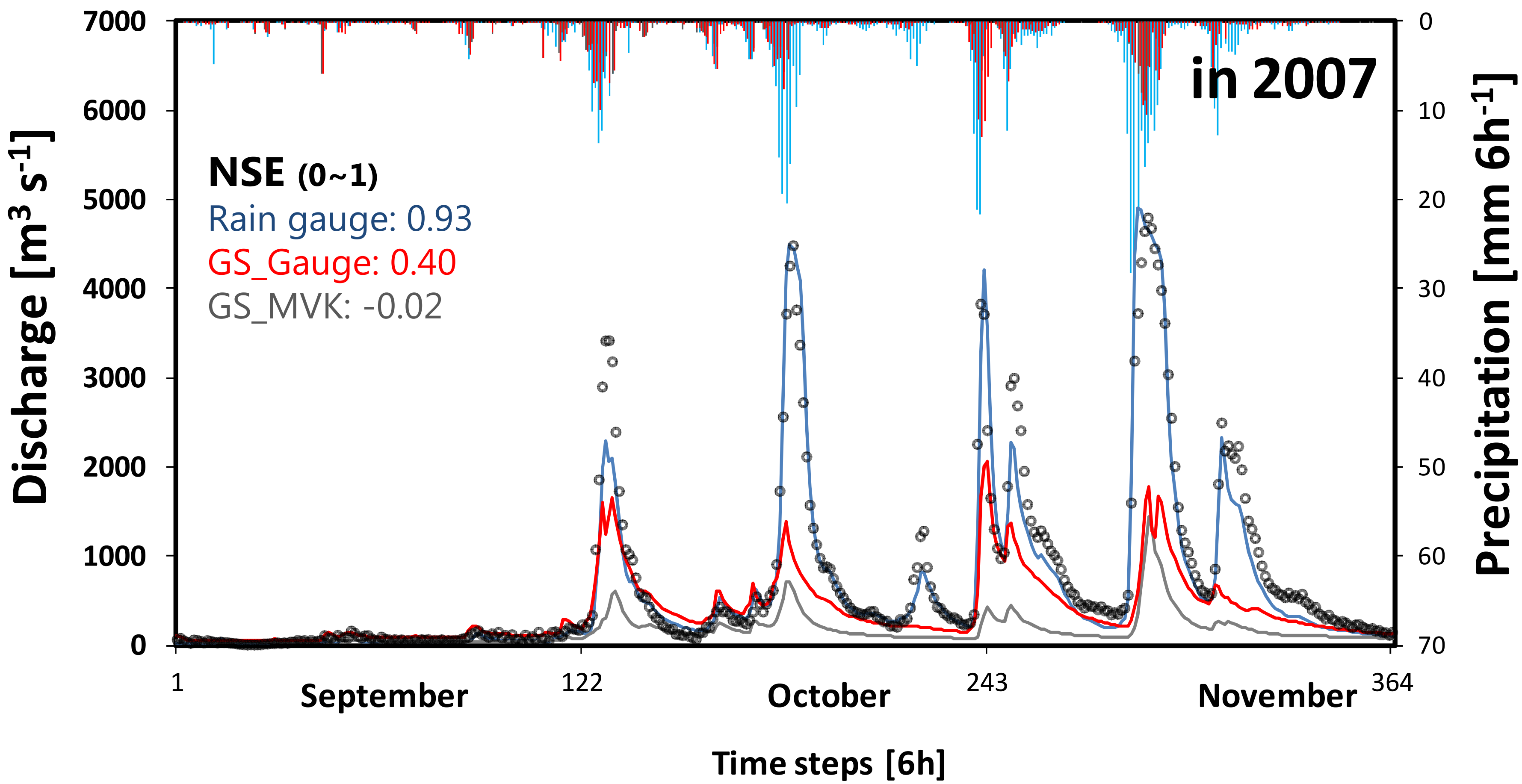
Discharge simulation rain gauge, Gauge, MVK



Discharge simulation with three types of precipitation inputs was conducted.

Local rain gauge network > GSMaP_Gauge >> GSMaP_MVK

Discharge simulation rain gauge, Gauge, MVK



Discharge simulation with three types of precipitation inputs was conducted.

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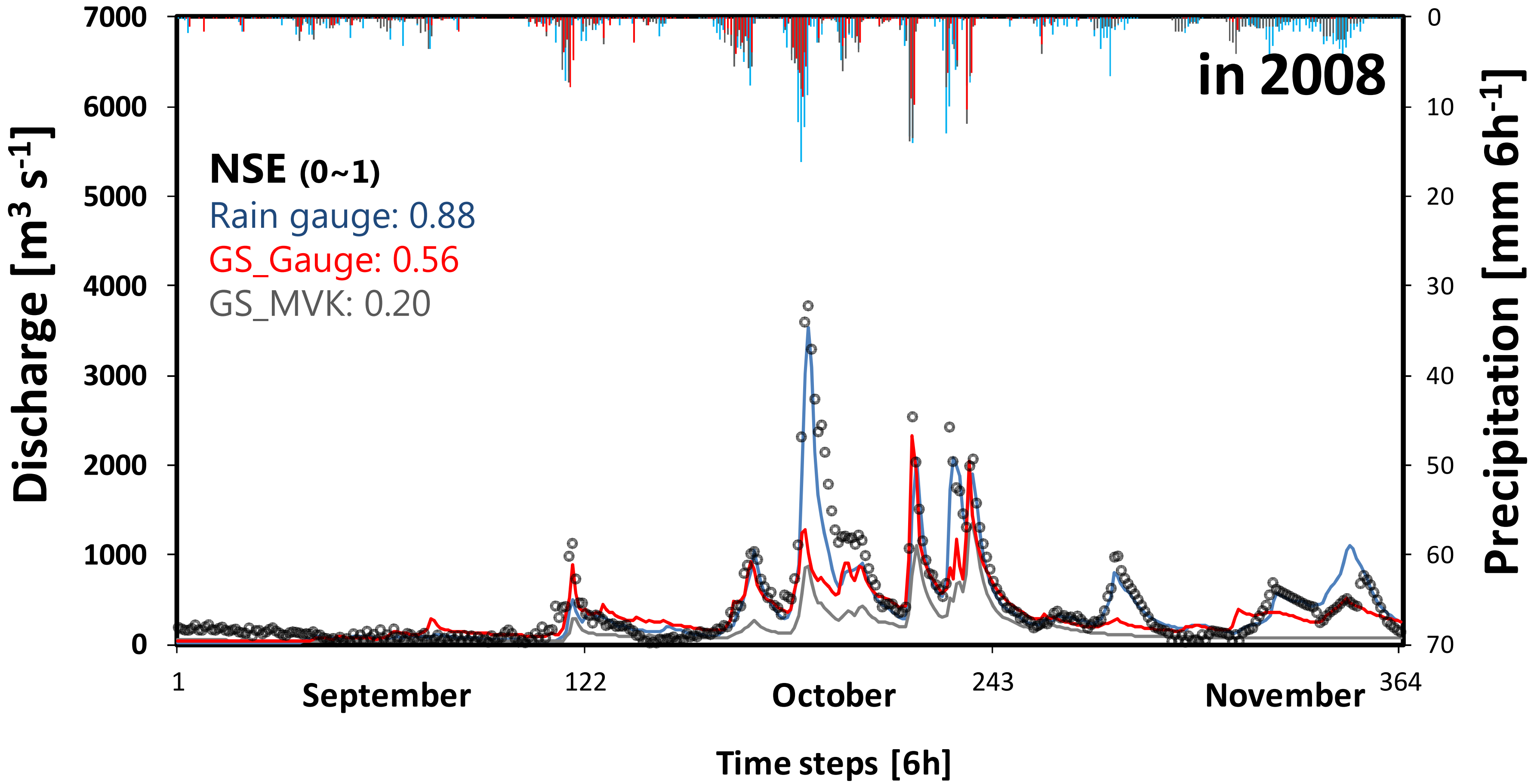
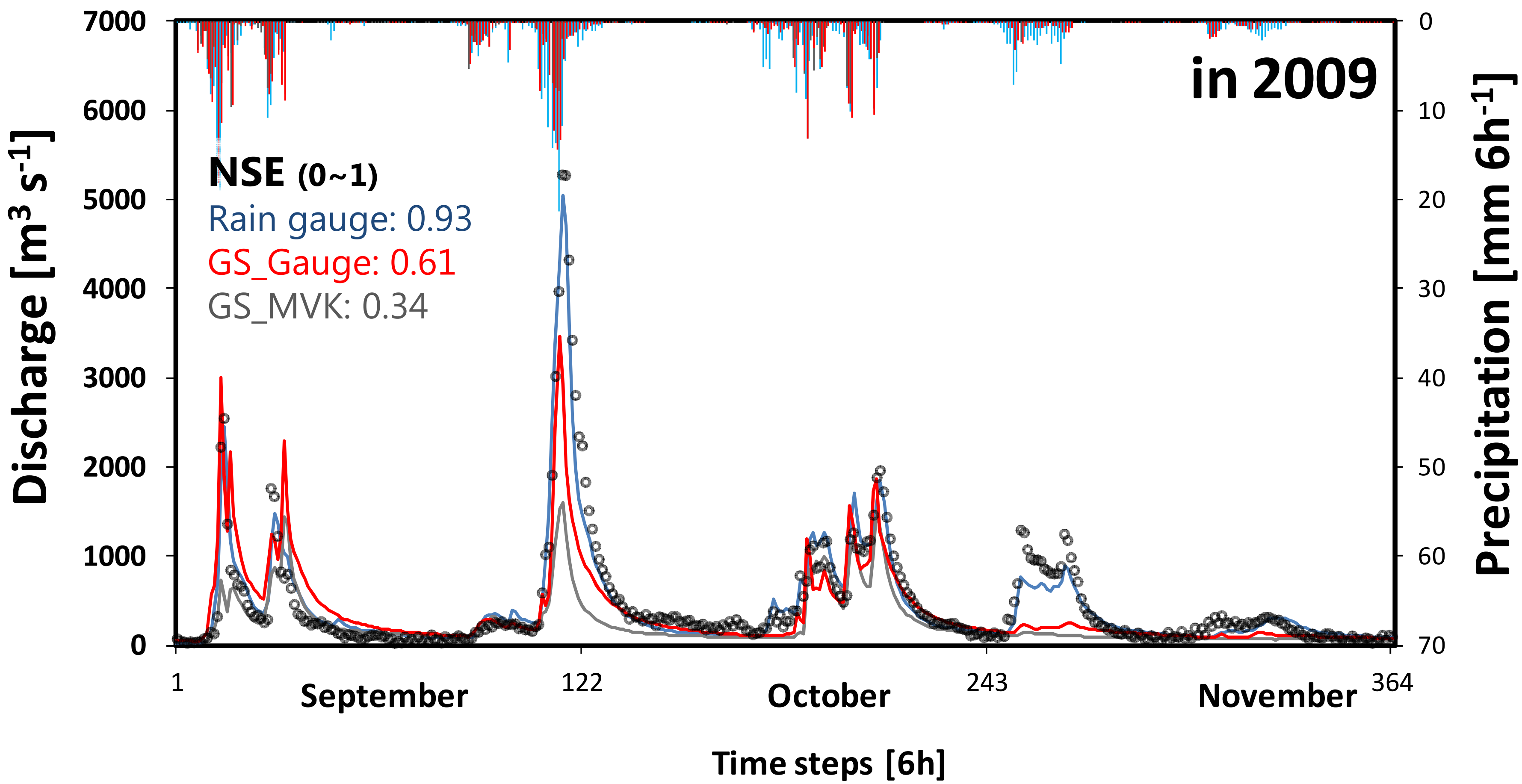
Discharge simulation rain gauge, Gauge, MVK



Discharge simulation with three types of precipitation inputs was conducted.

Local rain gauge network > GSMaP_Gauge >> GSMaP_MVK

Discharge simulation rain gauge, Gauge, MVK

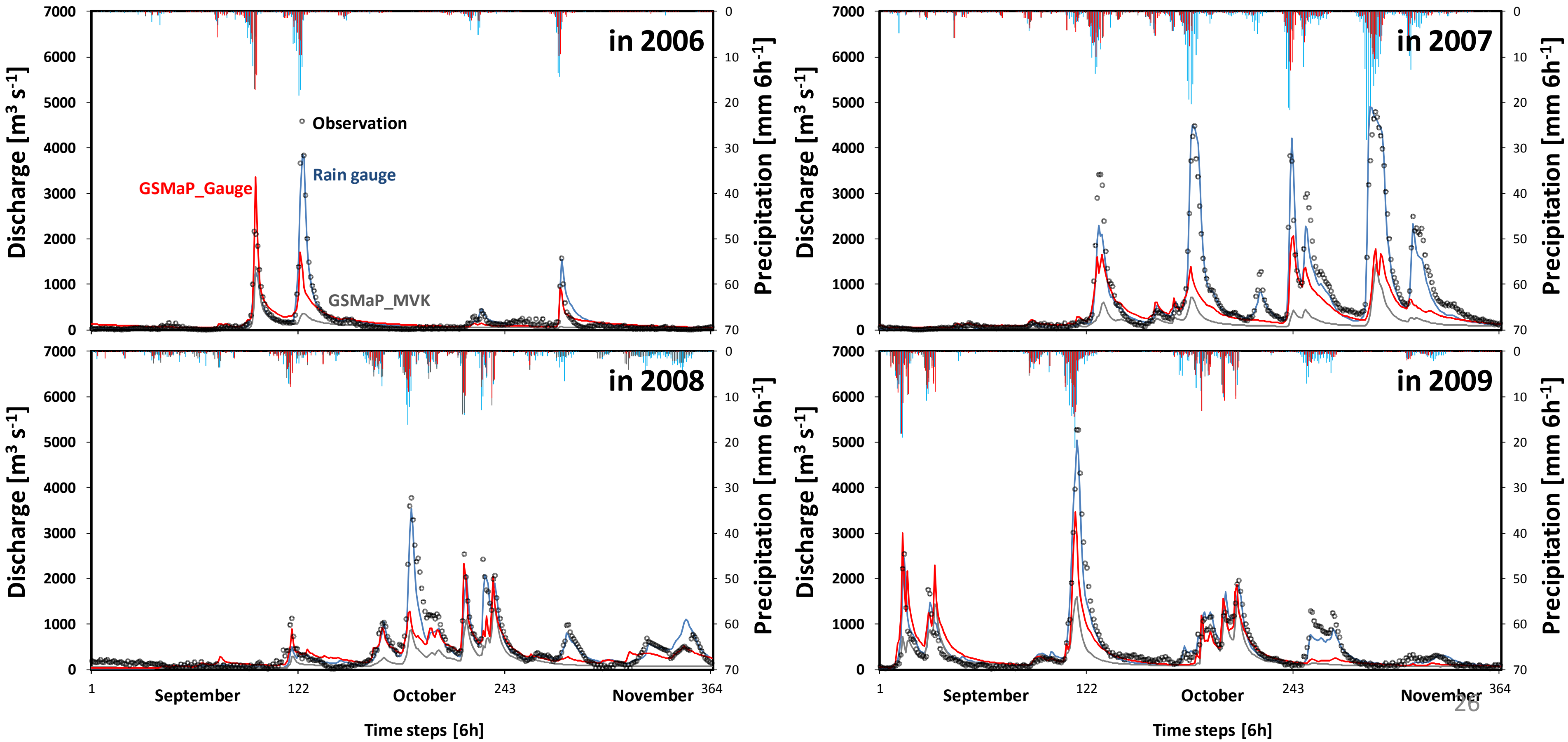


Discharge simulation with three types of precipitation inputs was conducted.

Local rain gauge network > GSMaP_Gauge >> GSMaP_MVK

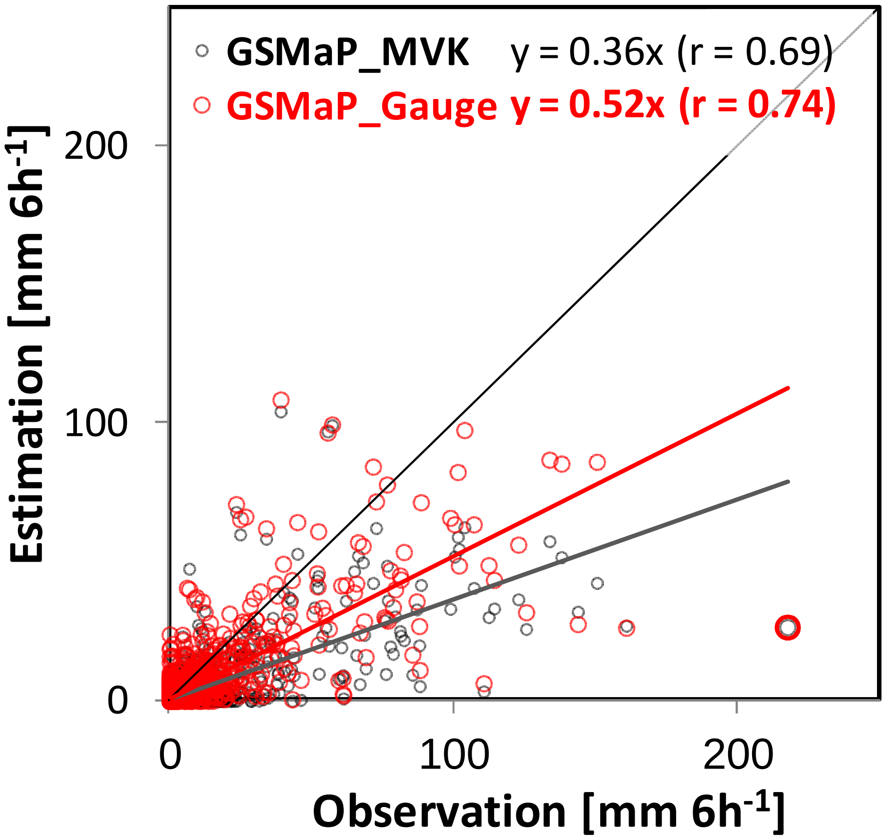
Discharge simulation evaluation scores

	2006			2007			2008			2009		
	Rain gauge	**Gauge**	MVK	Rain gauge	**Gauge**	MVK	Rain gauge	**Gauge**	MVK	Rain gauge	**Gauge**	MVK
NSE	0.93	**0.57**	0.19	0.93	**0.40**	-0.02	0.88	**0.56**	0.20	0.94	**0.61**	0.34
RMSE	130	**314**	432	258	**782**	1017	196	**370**	497	171	**421**	548
R	0.97	**0.79**	0.61	0.97	**0.85**	0.87	0.94	**0.81**	0.82	0.97	**0.80**	0.73
Bias	0.04	**-0.05**	-0.57	-0.09	**-0.46**	-0.78	-0.12	**-0.24**	-0.64	-0.02	**-0.18**	-0.48

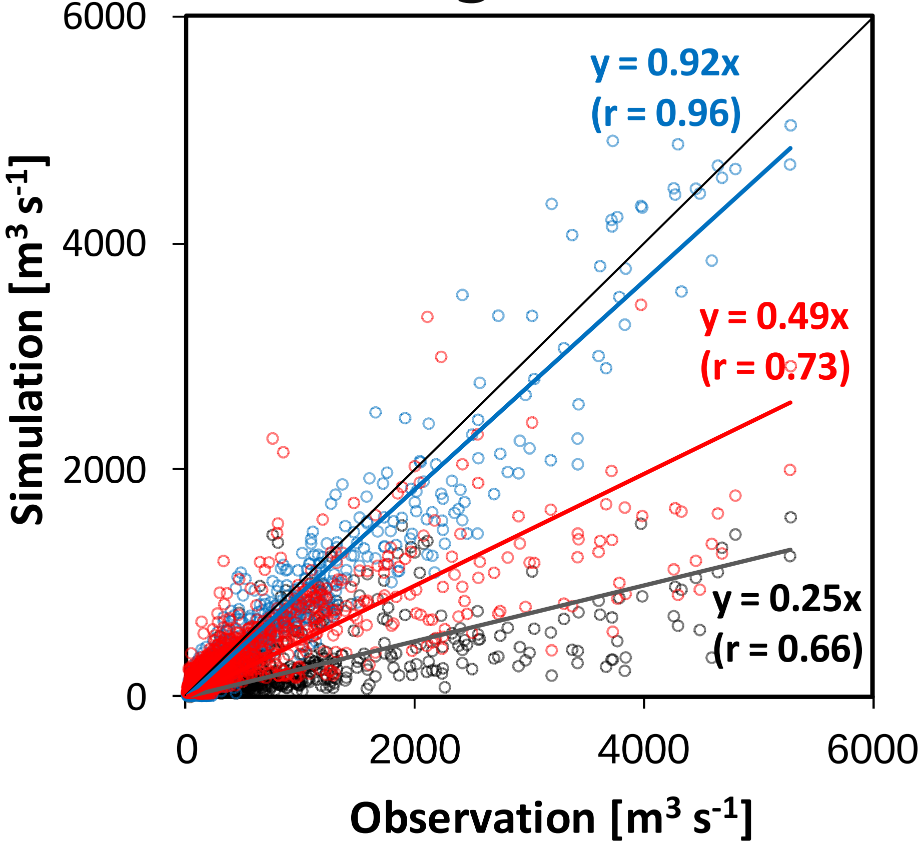


Precipitation vs. Discharge Linear regressions

Precipitation



Discharge



Tendency: underestimation

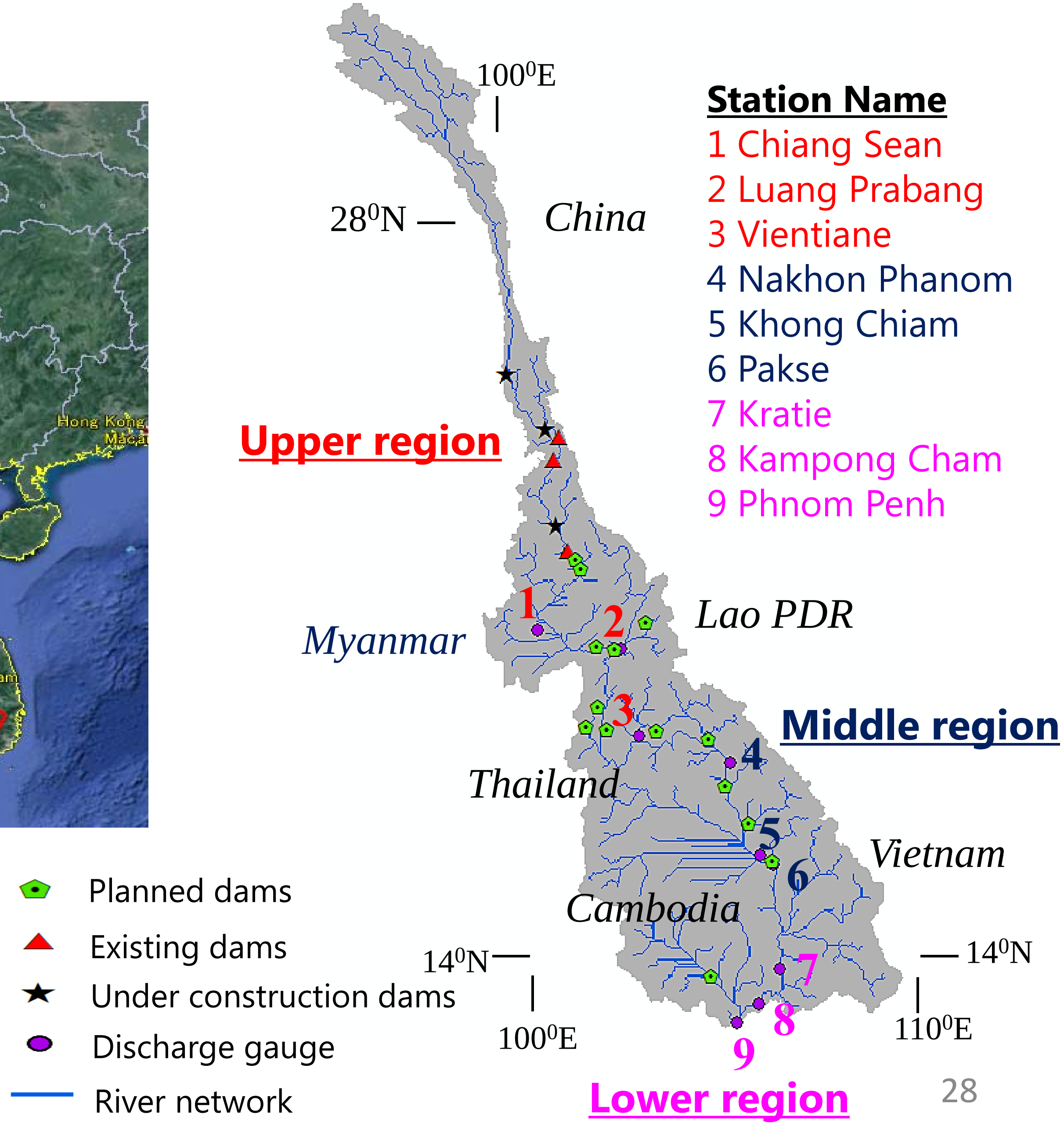
Correlation values do not become worse.

Slope of the regression of MVK reduced more than that of Gauge. → Evaporation

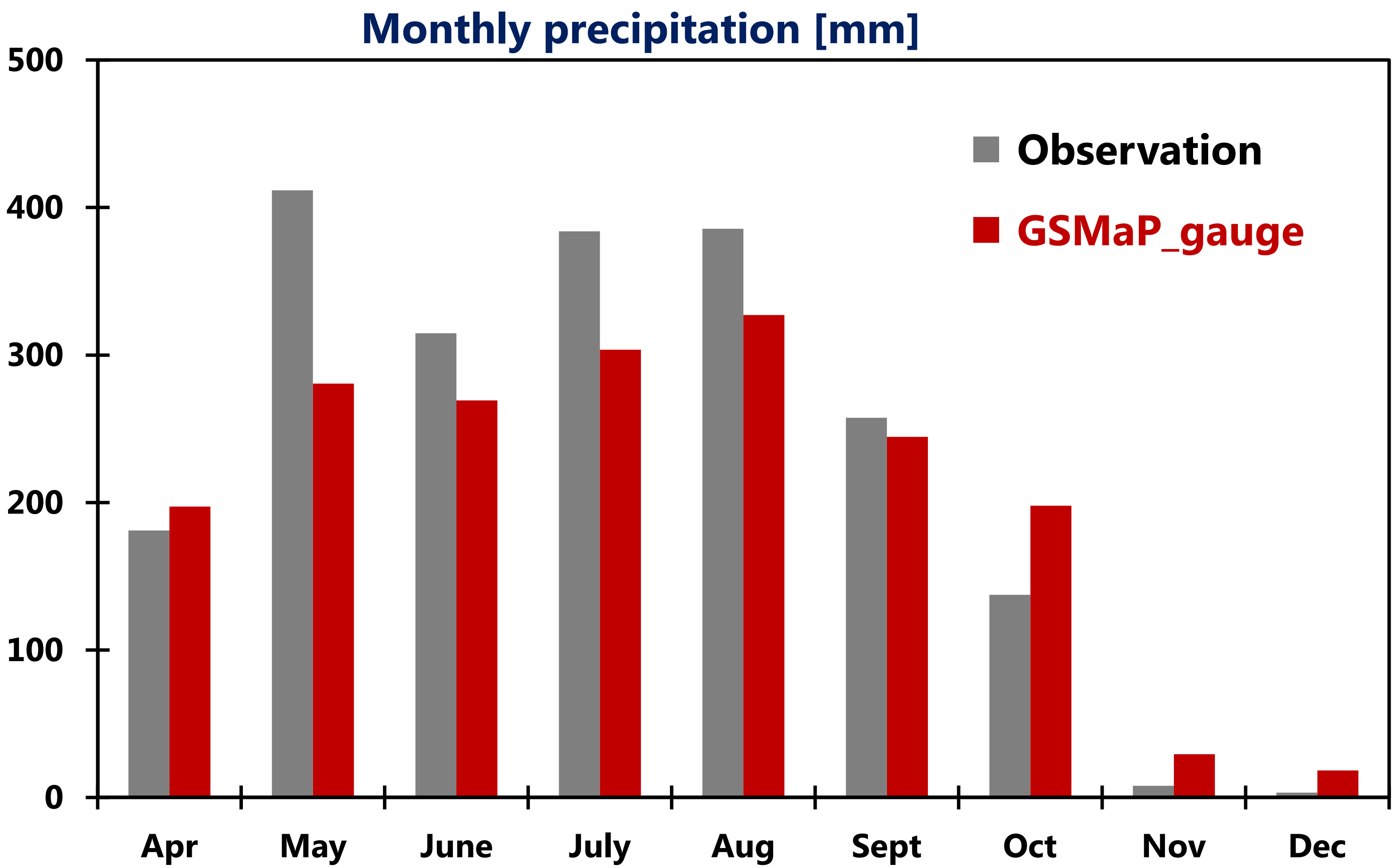
Application in Mekong River Basin

Area = 795,000 km²

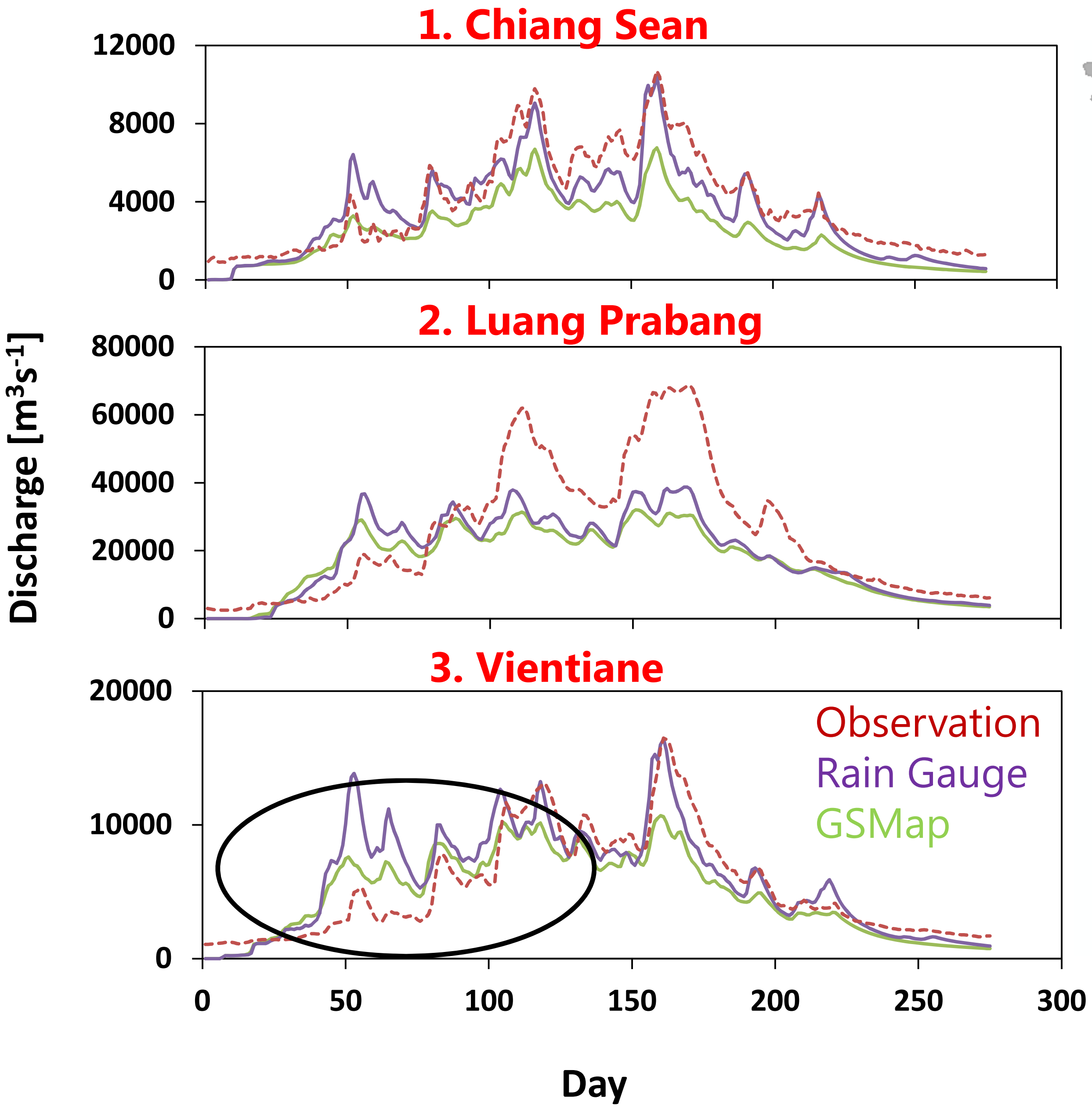
No. of Obs. Gauges: 65 stations
Annual prec, Min = 1000 mm
Max = 4000 mm
Mean Discharge : 15,000 m³/s
Max Discharge : 45,000 m³/s

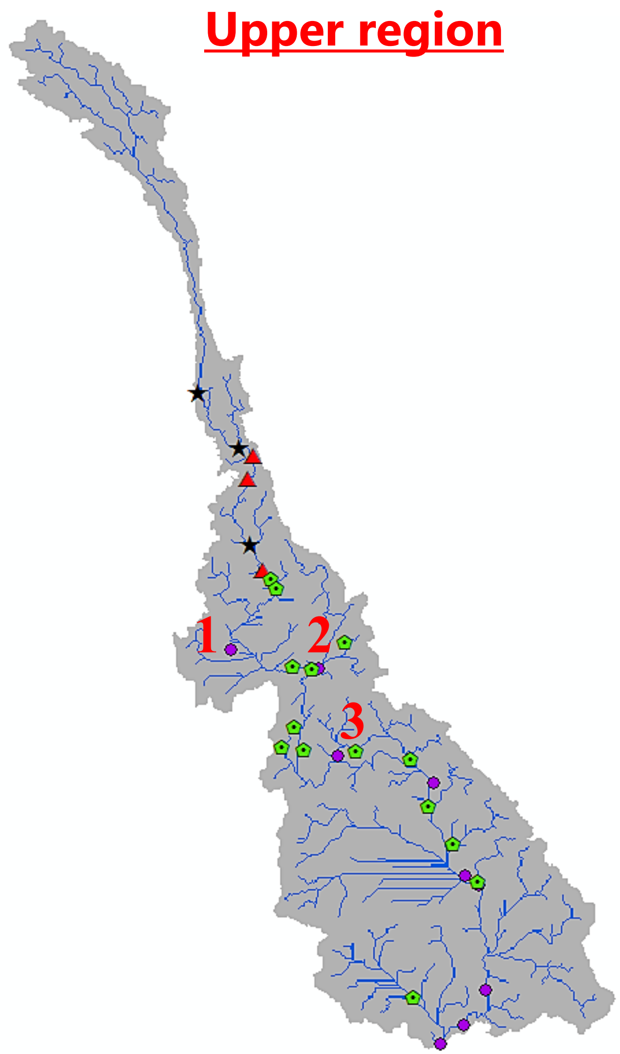


Monthly precipitation April – December 2000

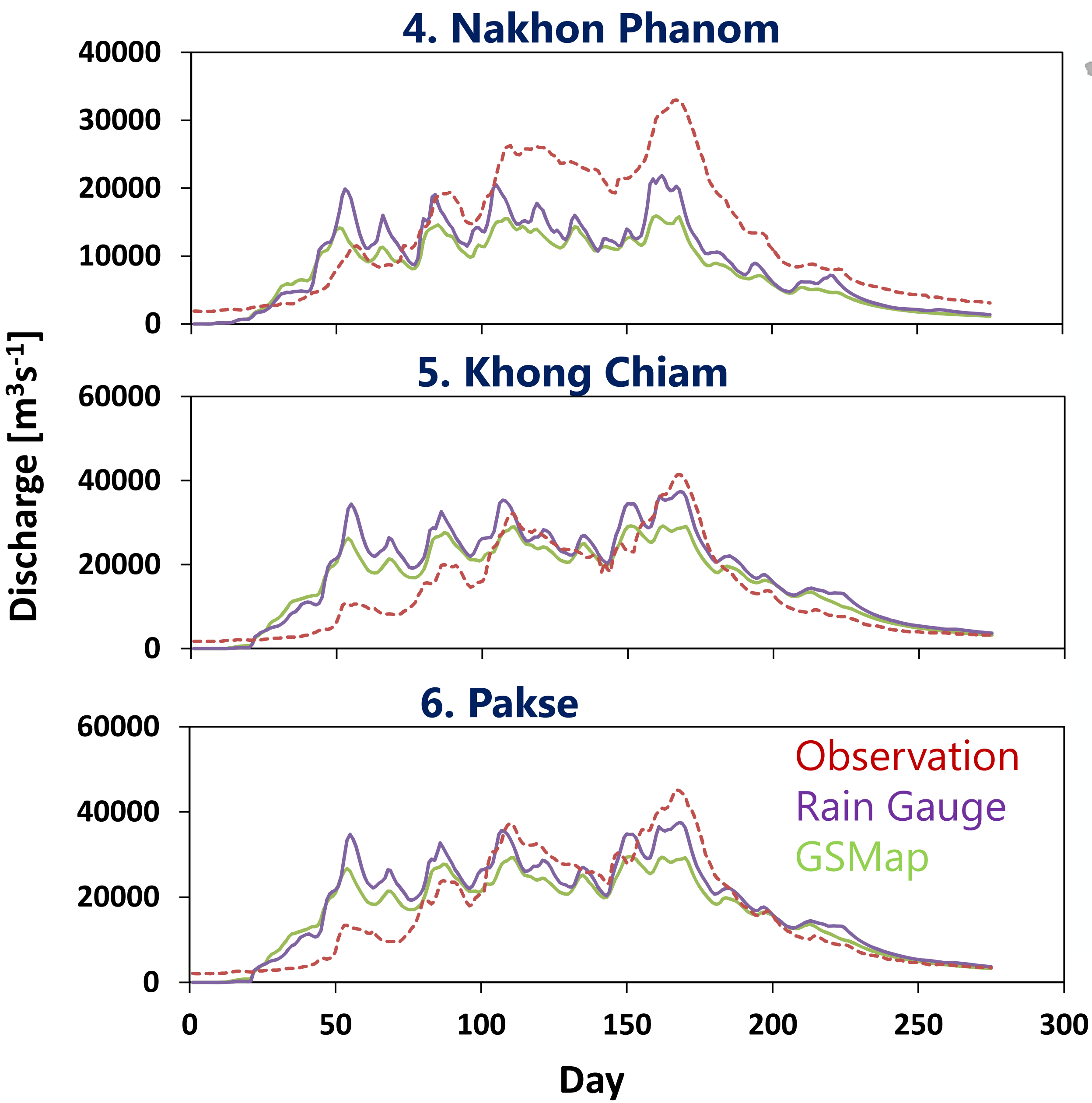


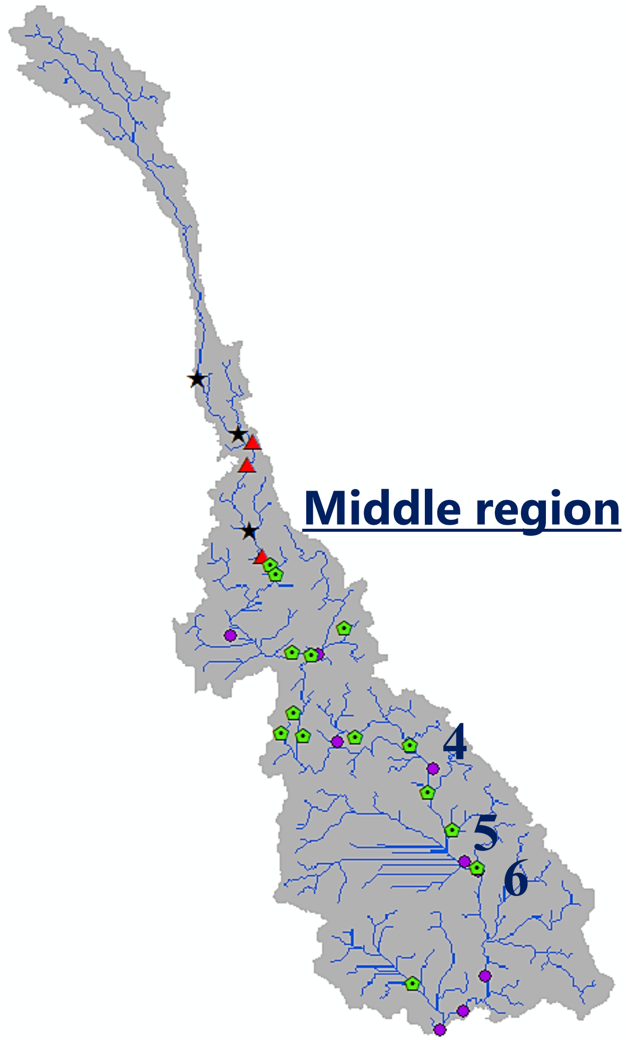
Daily Discharge simulation rain gauge, GSMaP



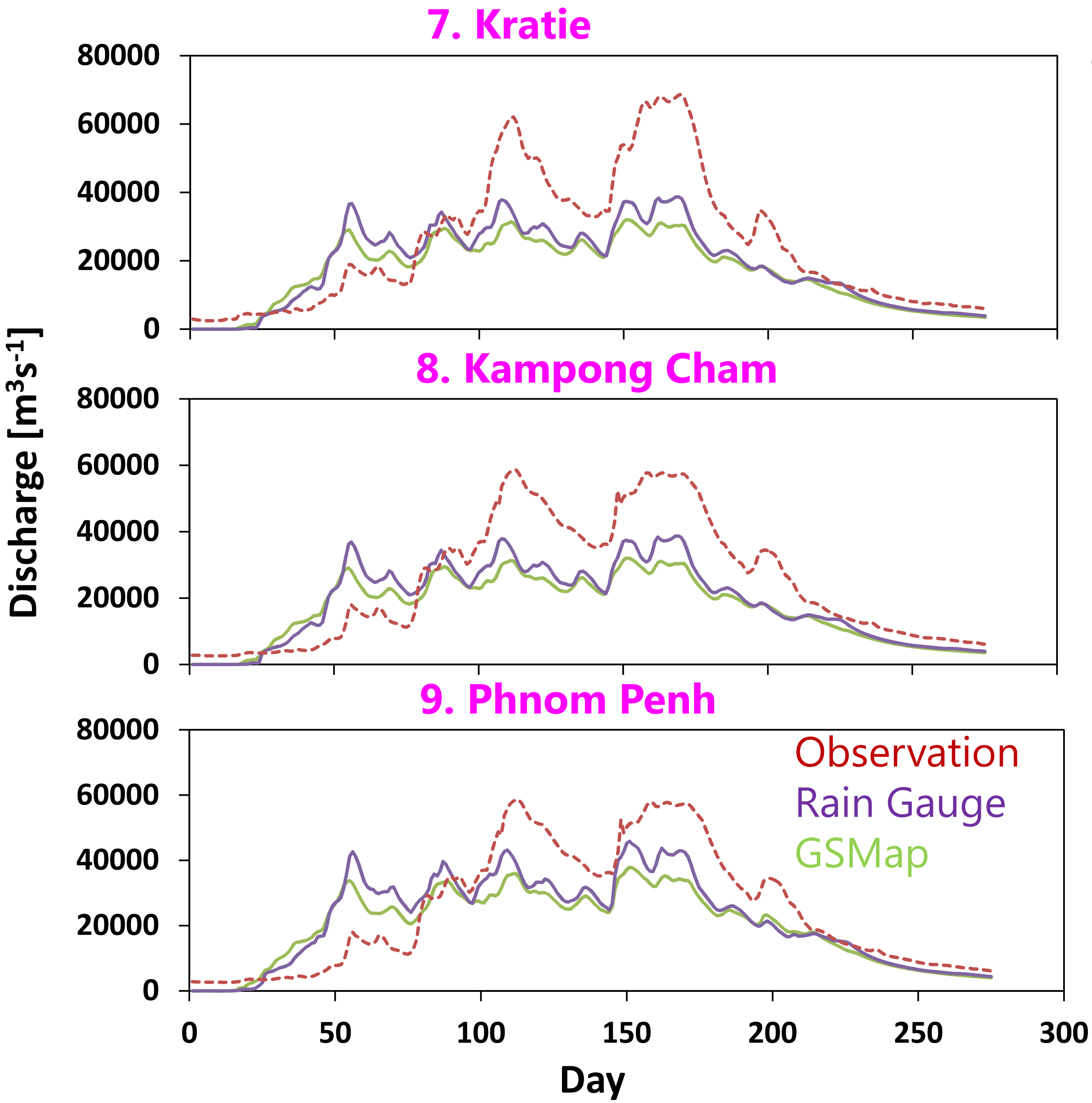


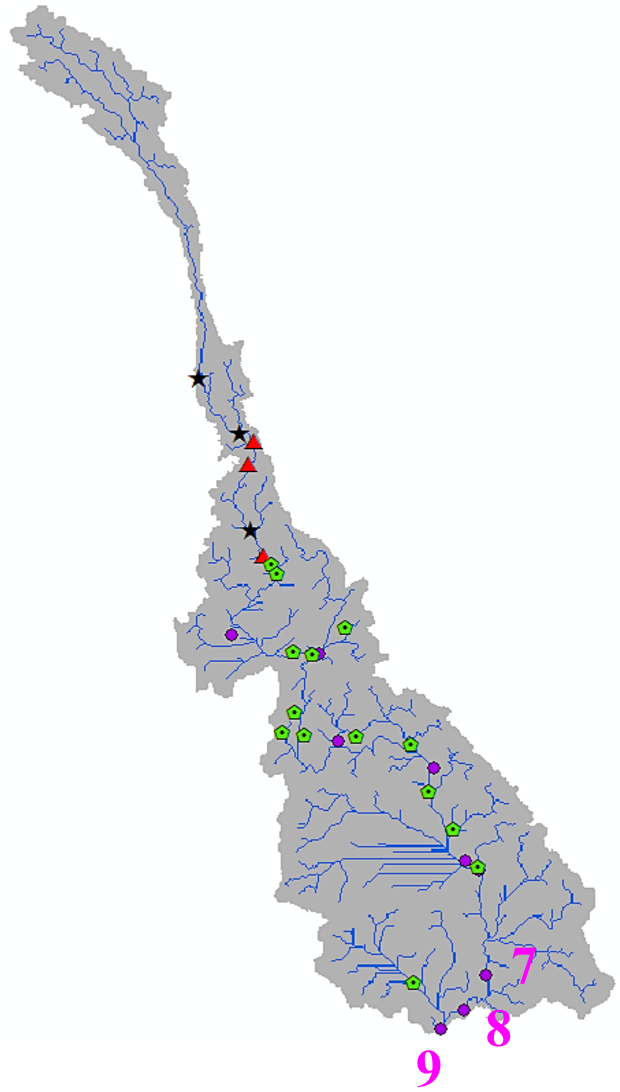
Daily Discharge simulation rain gauge, GSMaP





Daily Discharge simulation rain gauge, GSMaP





Lower Region

Findings so far

- We achieved temporal downscaling daily→6h
- Statistical evaluation, GSMap_gauge > GSMap_MVK

  POD & FAR at Tone and Huong
- Significant improvement of the prec. estimation 10-100 [mm d^{-1}] and slight improvement at intensities (> 100 [mm d^{-1}])
- Timing of rising limbs (rapid increase of discharge, start of flooding) was captured very well.
- Underestimation tendency of peak discharge during floods
- Overall GSMap_MVK 's underestimation has been reduced by GSMap_gauge but still some bias can be found even overestimation
- Evaluation seems sensitive on the quality and density of obs prec

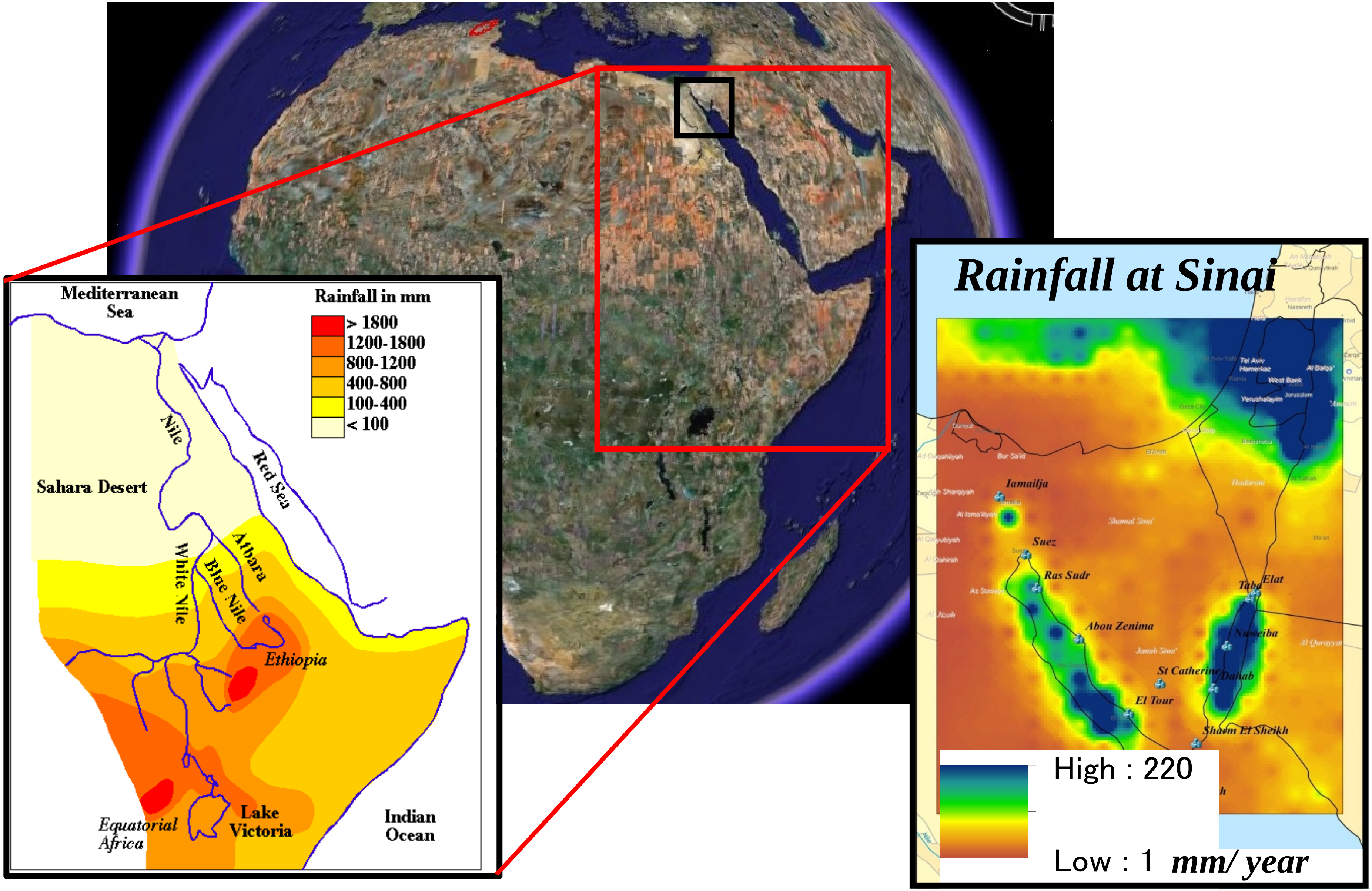
Publications

- Takido K., Tanuma, Ryo, M, O. Saavedra, T. Ushio, and K. Kubota: Tempo-Spatial Evaluation of a new Satellite Precipitation Product GSMaP_Gauge over Tone River Basin in Japan ***, Journal of Japan Society of Meteorology***, under preparation.
- Ryo M., O. Saavedra, S. Kanae, and N. D. Tinh,: Temporal downscaling of daily gauged precipitation by application of a satellite product for flood simulation in a poorly gauged basin and its evaluation with multiple regression analysis, ***Journal of Hydrometeorology***, in press.
- Saavedra, O., Ryo, M. and Tanuma, K. (**2013**): Ground validation of satellite-based precipitation for flood simulation in South-East Asian River basins, *17th International Water Technology Conference (IWTC)*, Istanbul, 5-7 Nov 2013, 6 pp
- Tanuma, K., Saavedra Valeriano, O.C., and Ryo, M. (**2013**): Spatial variability of precipitation and soil moisture on the 2011 flood at Chao Phraya River Basin, *17th International Water Technology Conference (IWTC)*, Istanbul, 5-7 November 2013, 8 pp

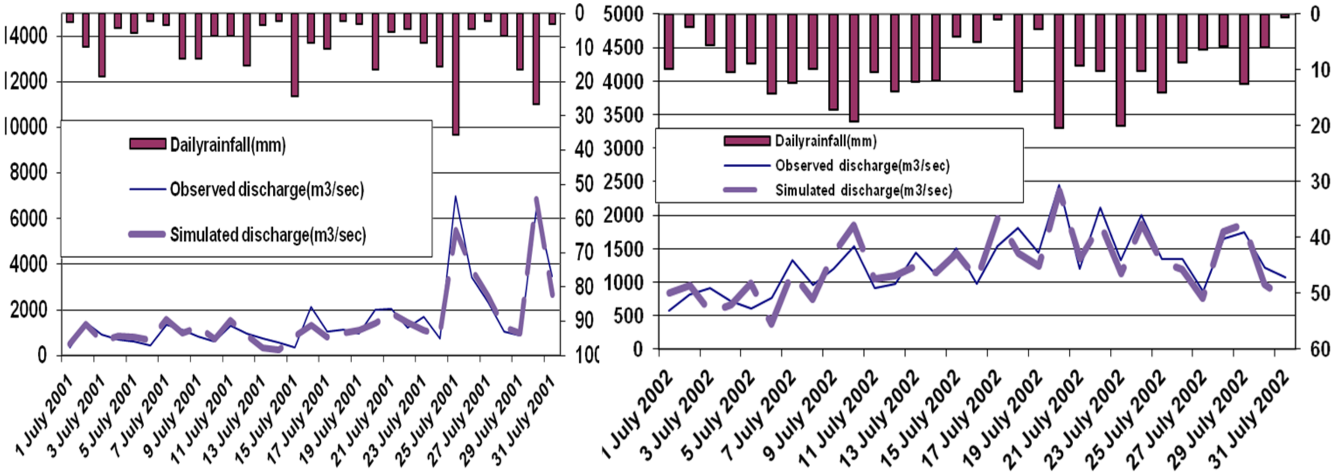
Schedule

JFY	2013				2014				2015			
Month	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3
-TRMM & GSMap validation	←	—	—	—	—	—	—	—	—	—	—	→
-Hydrological simulations				←	—	—	—	—	→			
-Near real-time applications							←	—	—	—	—	→
- Statistical evaluation of TRMM and GSMap against available gauge network at selected Asian and African basins	←	—	—	—	—	—	—	→				
- Suggestion of proper correction factors for TRMM and GsMap data set at selected Asian and African basins				←	—	—	—	—	→			
- Validation of correction factors for TRMM and GsMap data set at selected Asian and African basins						←	—	—	—	—	→	
- Development of enhanced data set for those selected basins							←	—	—	—	—	→

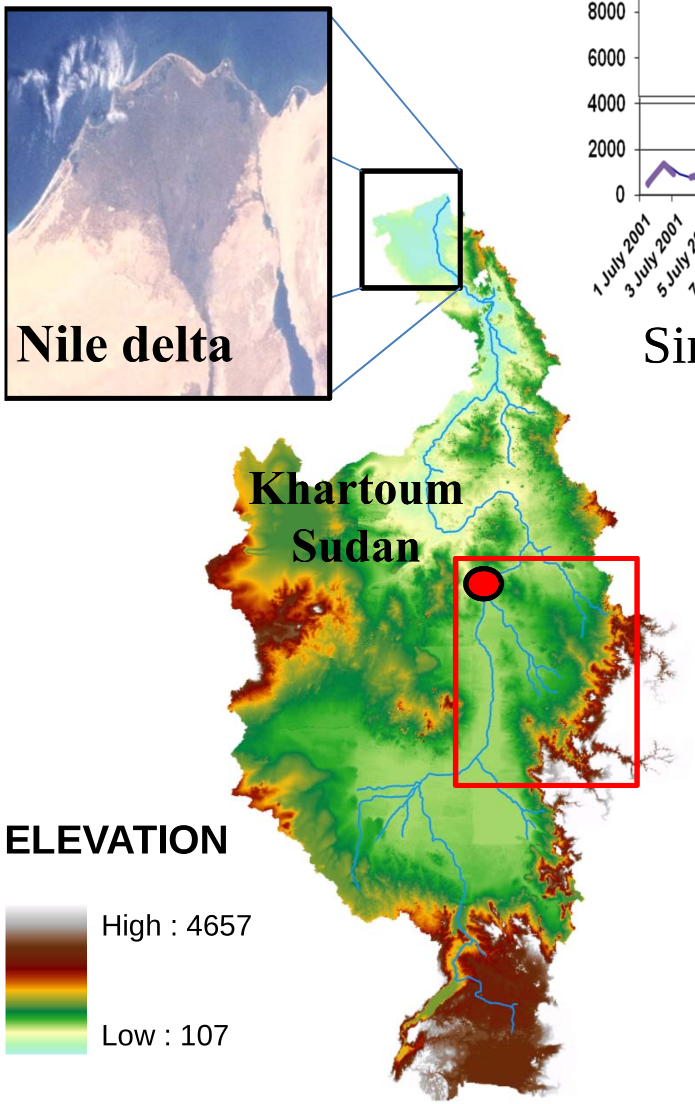
Applications in African region
Eastern Nile river and Sinai Peninsula

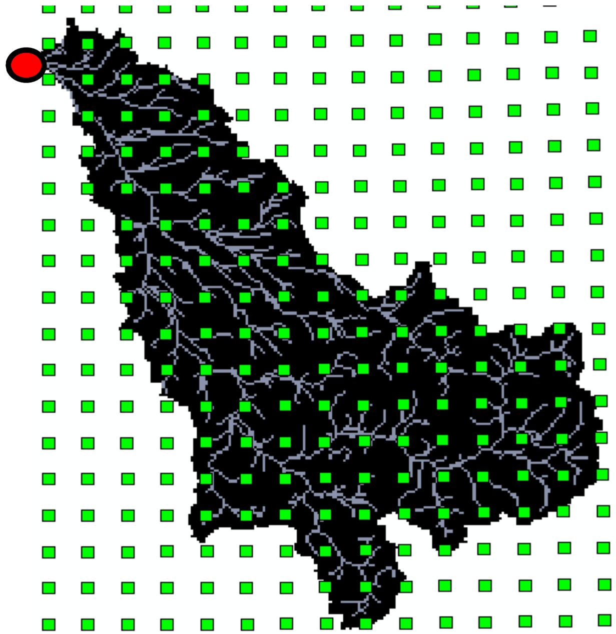


Results of Nile River discharge at Sudan

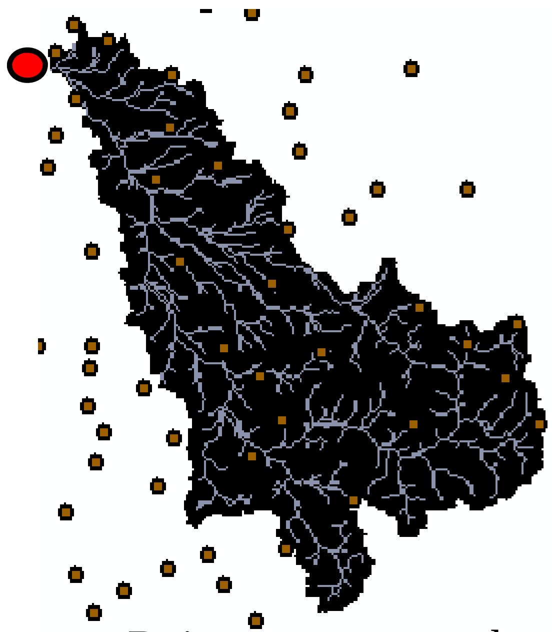


Simulated stream flow using rain gauge at Khartoum st.



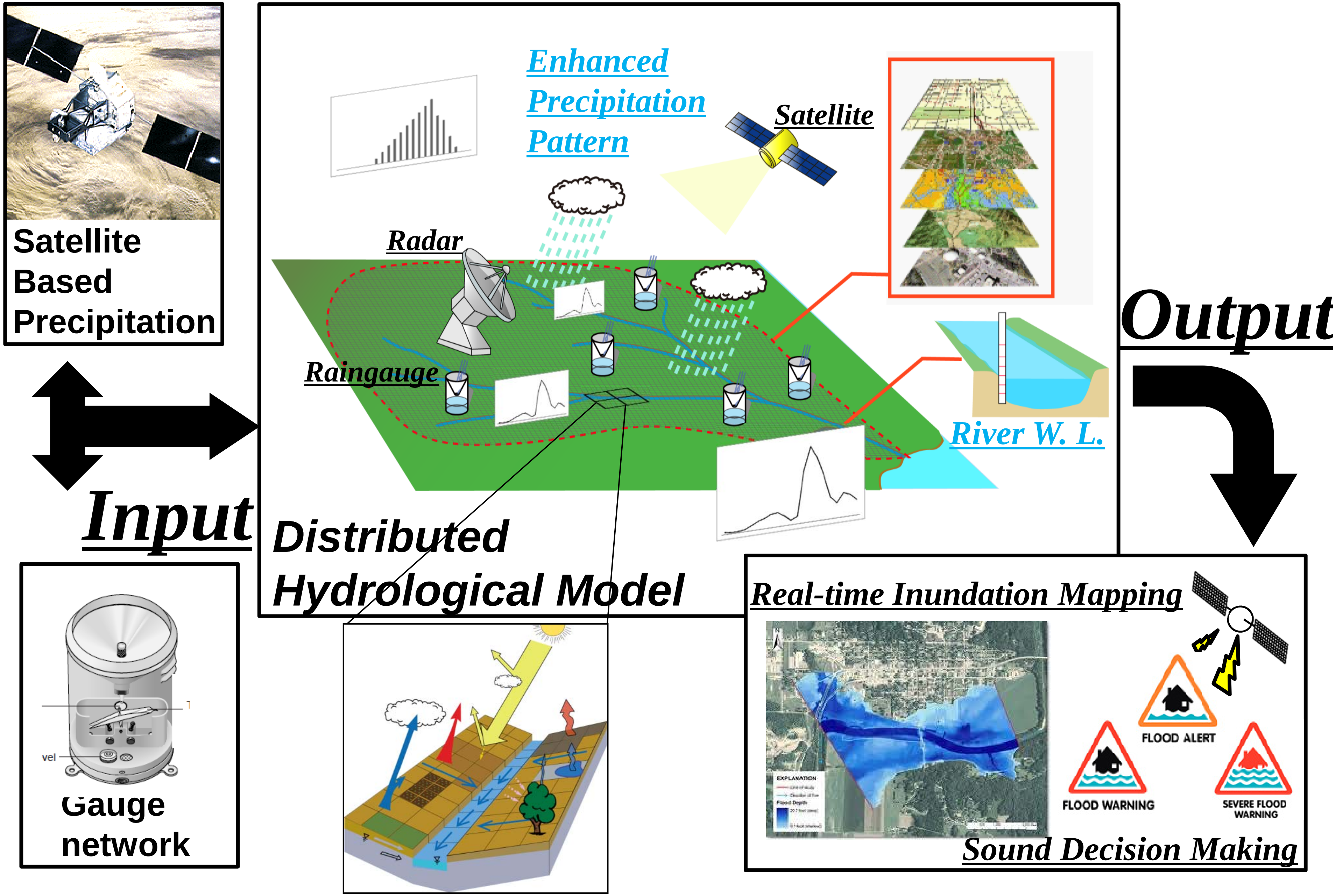


TRMM distribution

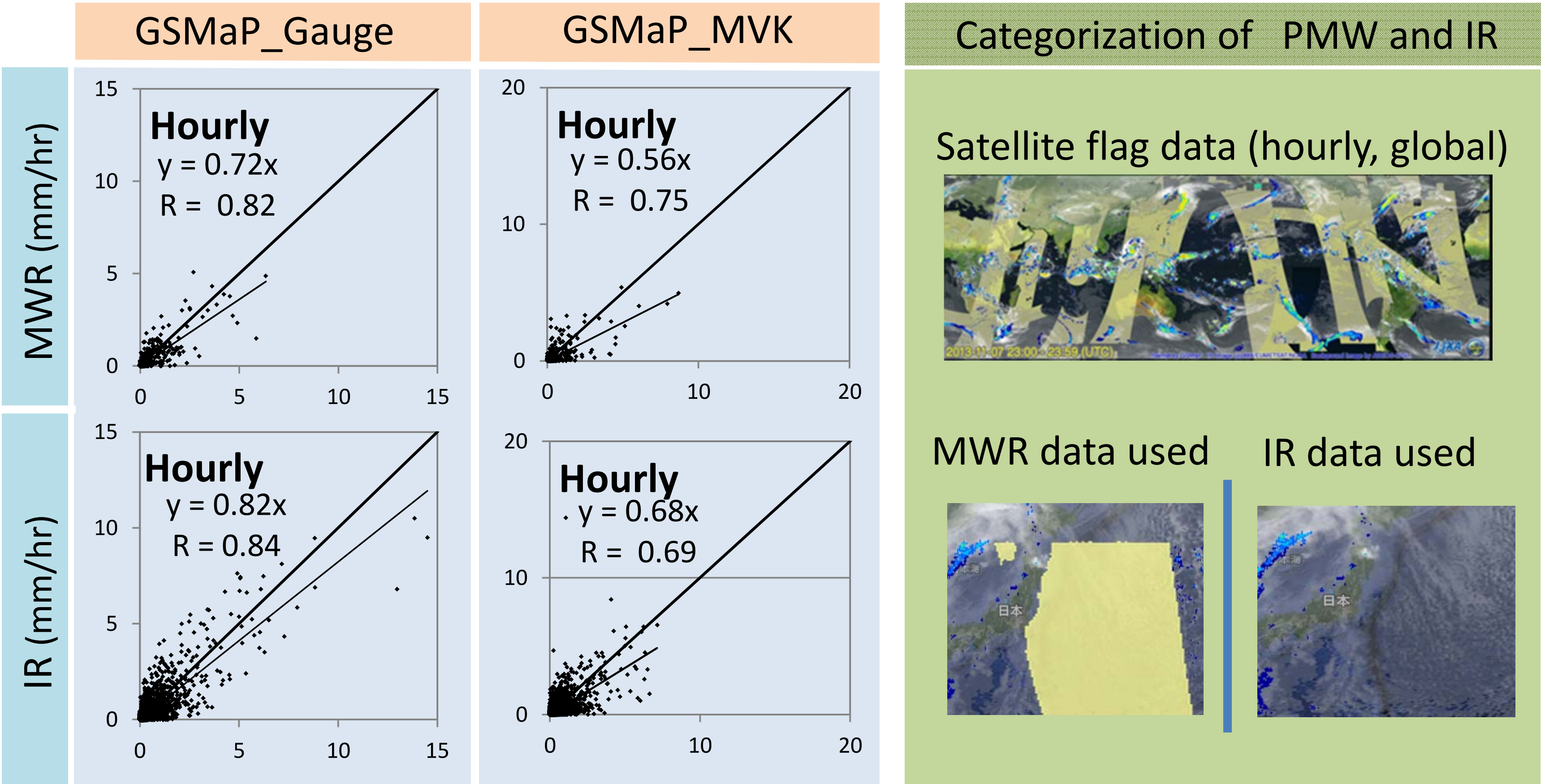


Rain gauge network

Flood management support system



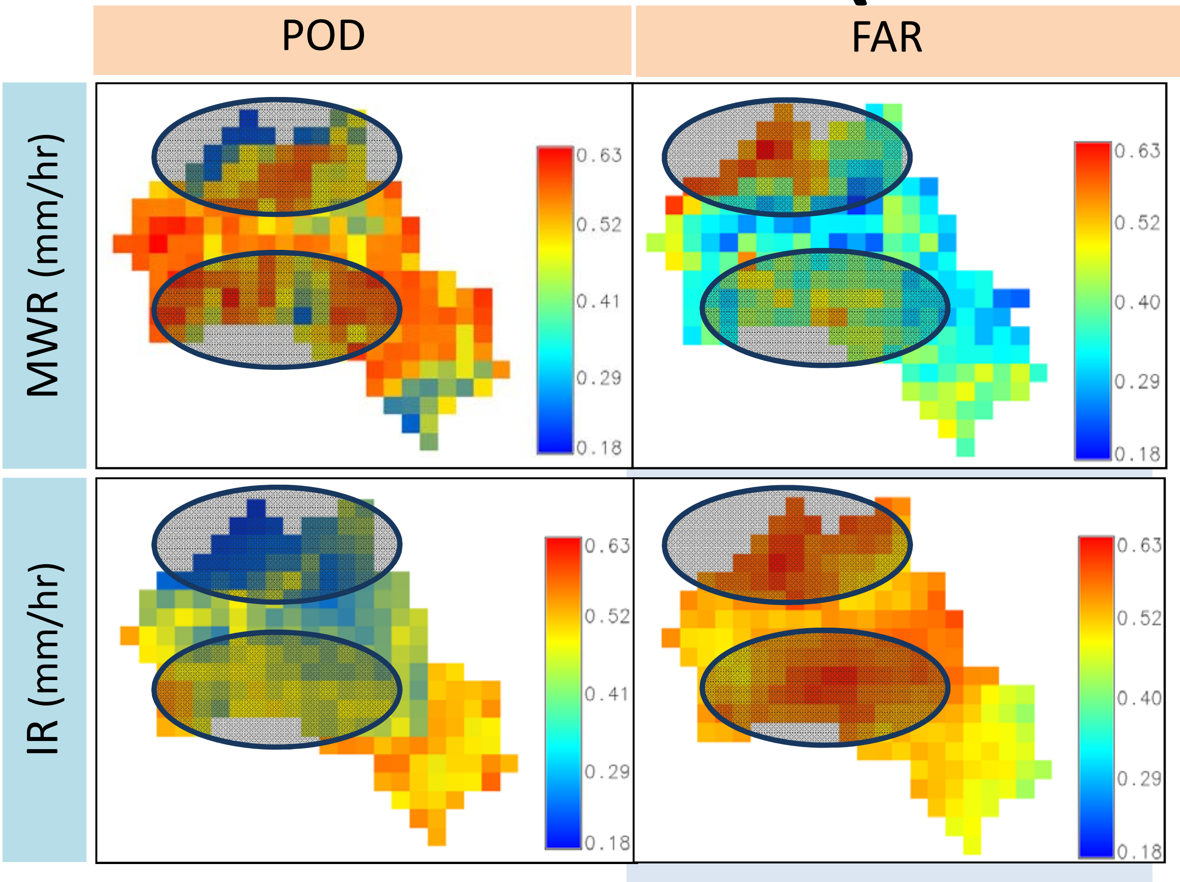
Difference in accuracy between PMW and IR



For GSMaP_MVK: values more constant for MWR, alleviation of underestimation for IR + MVK

For GSMaP_Gauge: Stronger correlation for IR + MVK, alleviation of underestimation for PMW

Difference in POD and FAR between PMW and IR (for MVK)



Overall, MWR was better for both POD and FAR

Some resemblance in tendency could be seen between MWR and IR

As expected where POD is low, FAR is high

Daily precipitation April – December 2000