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2012 / 11 / 27

N C H C

Development of a Flood Ensemble Forecast System in Taiwan

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NCHC
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國家高速網路與計算中心
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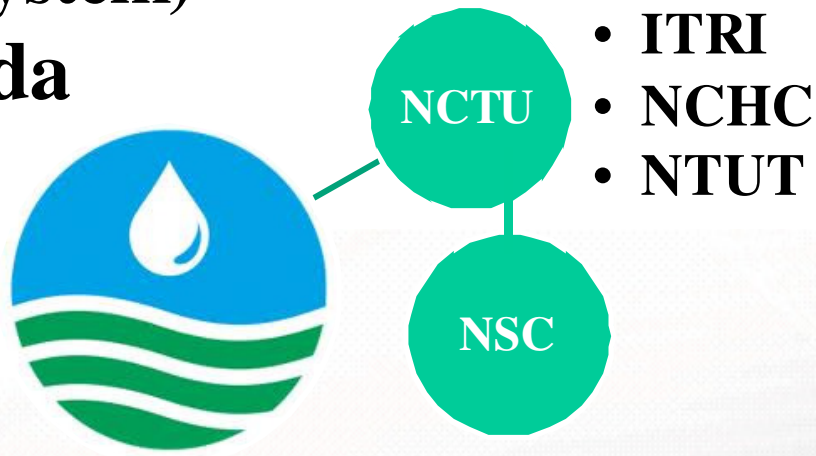
Outline

- Introduce
- Water level forecasting(1D)
  - Introduction to real-time flood forecasting system
  - Forecast of Rainfall, runoff and water level
  - Improvement of the difference between forecasting data and observation data
- Flood inundation forecasting(1D/2D)
  - Test case study
- Ensemble water level forecasting
  - Test case study
- Conclusions

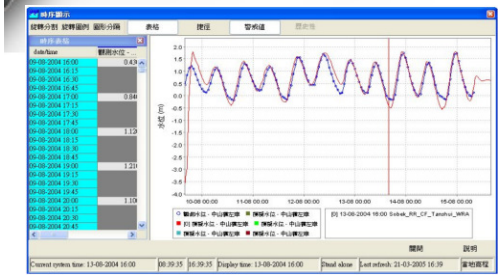
Collaborations between WRA and Deltares

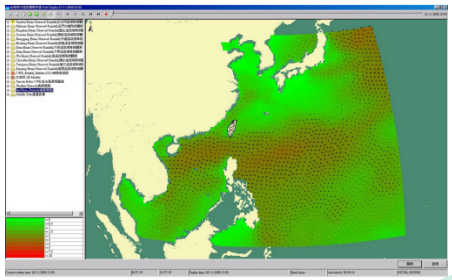
- **Initial contact from 1983**
  - Taiwan became the test base of FEWS (Flood Early Warning System)
- **Team member and agenda**
  - WRA 2001
    - Water Resource Agency
  - WRA,NCTU 2002~2006
  - WRA,NCHC 2006~2008
    - NSC
  - WRA,NTUT 2009~

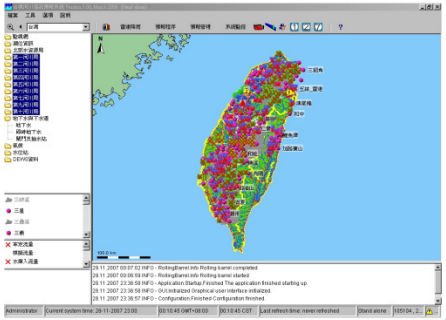


- **Representatives**
  - Dr. M.J. Horng (WRPC ➡ WRB ➡ WRA)
  - Ir. Simon Groot(Delft Hydraulics ➡ Deltares)

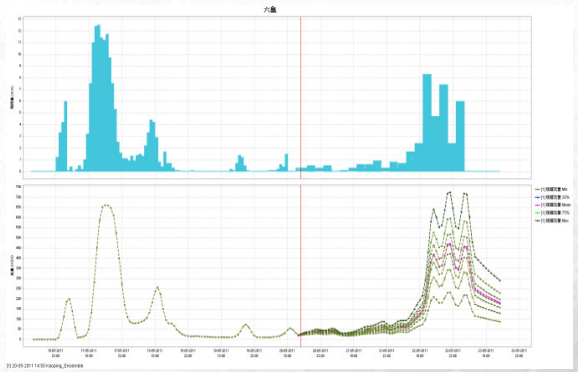
Three Stages of FEWS_Taiwan





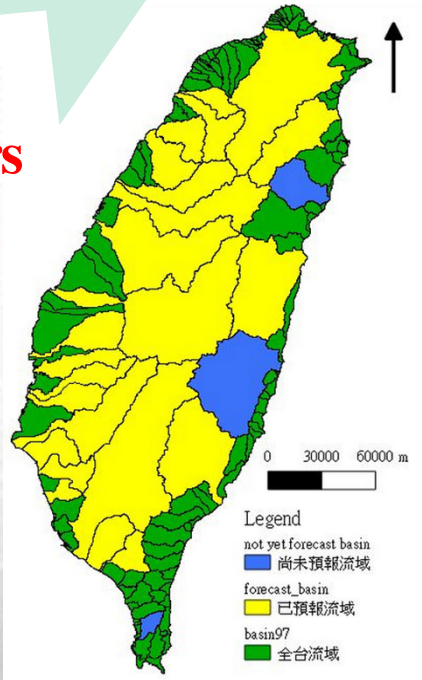


Research Stage 2001~2005
5 rivers



Test Stage 2006~2009
19 rivers

Operational Stage 2009~
23 rivers



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Water level Forecasting (1D simulation)

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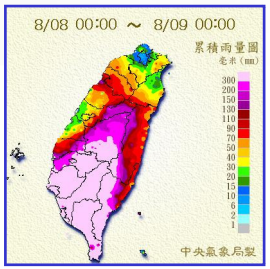
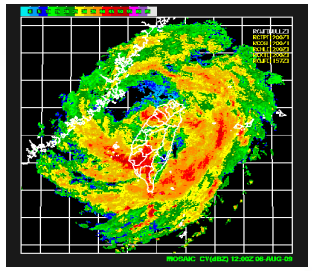
NATIONAL CENTER FOR HIGH-PERFORMANCE COMPUTING

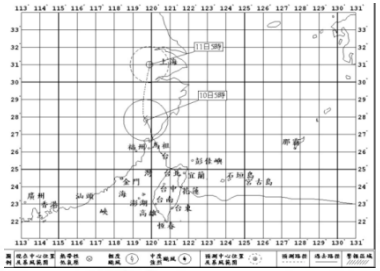
Process of water level forecasting based on FEWS_Taiwan

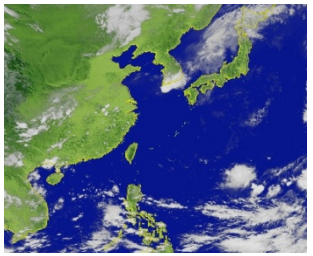
2. Quantitative precipitation forecast



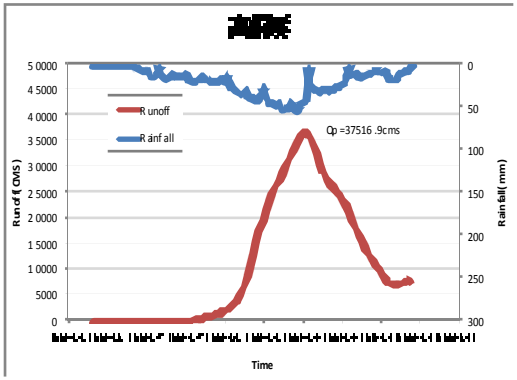


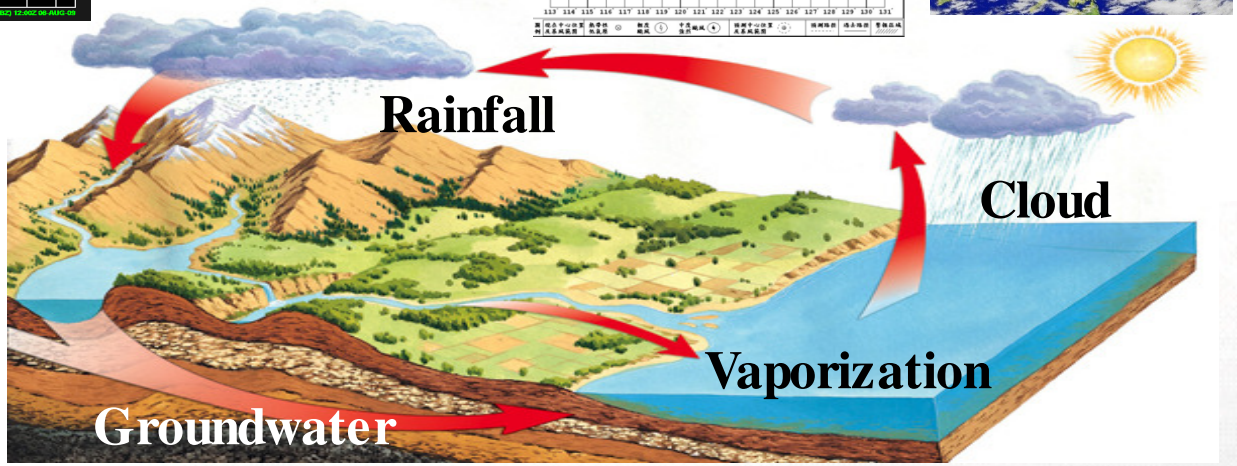
1. Forecast of typhoon track





3. Runoff routing





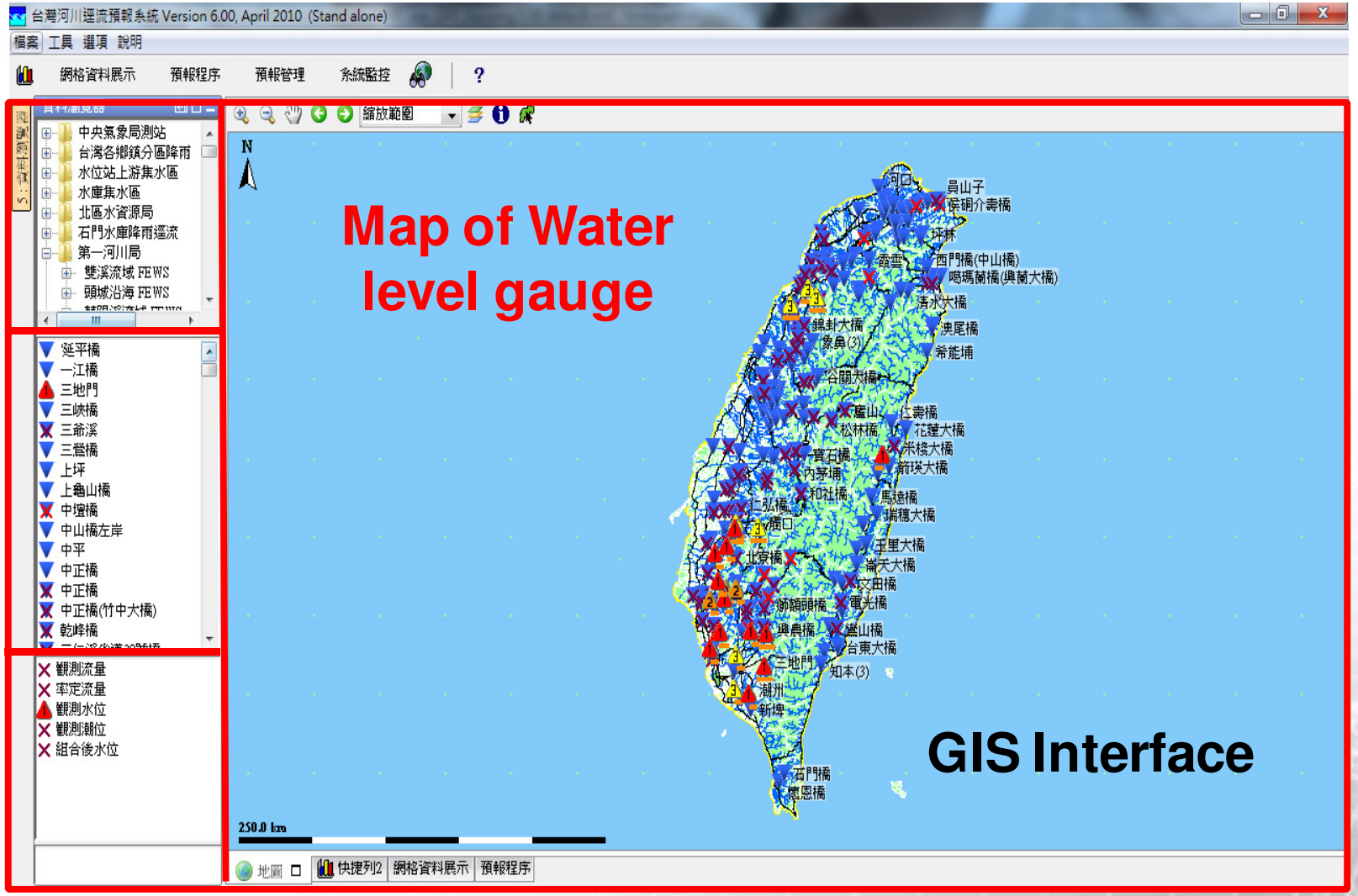
4. Channel routing

Layout of FEWS_Taiwan

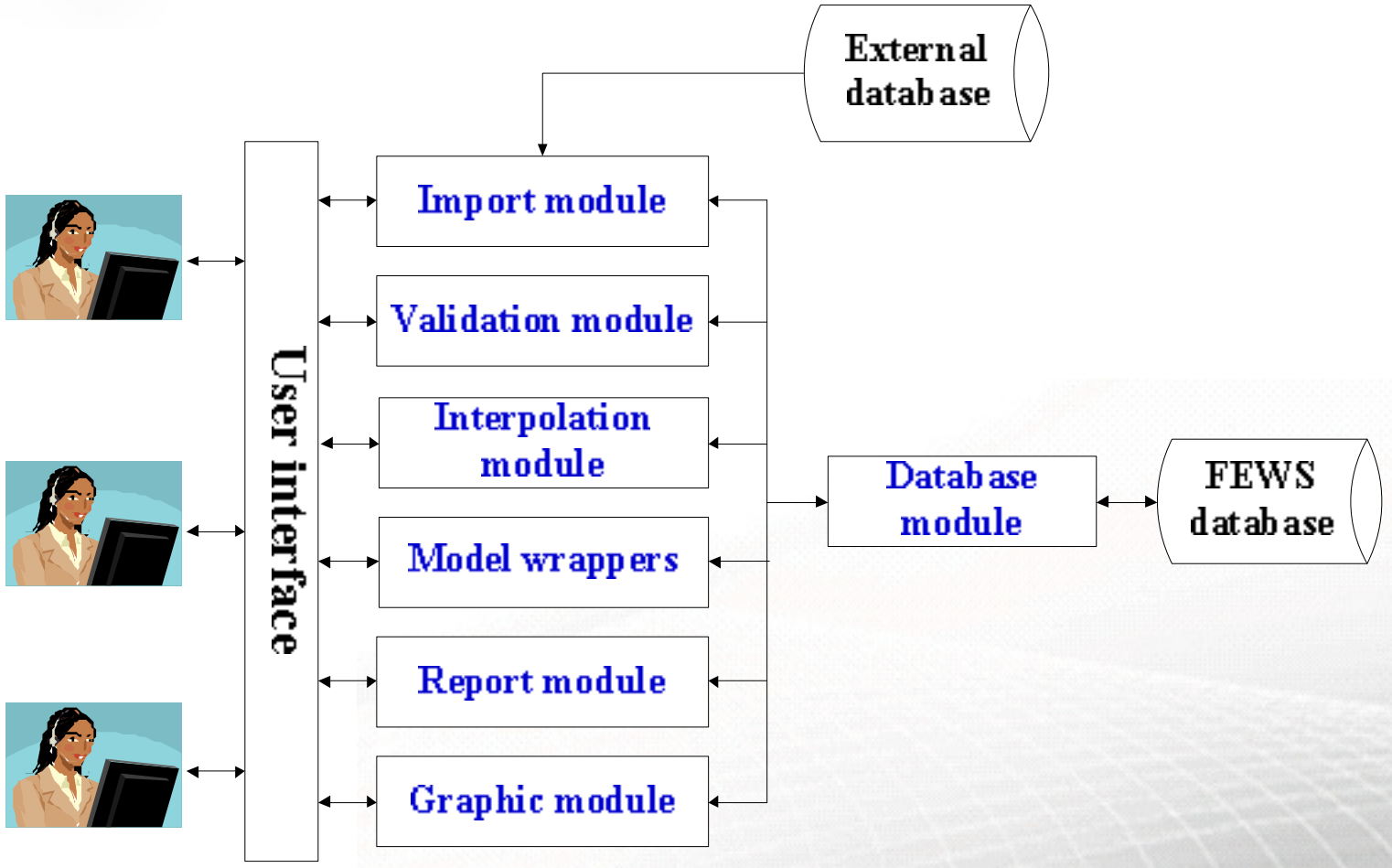
River

Gauge Station

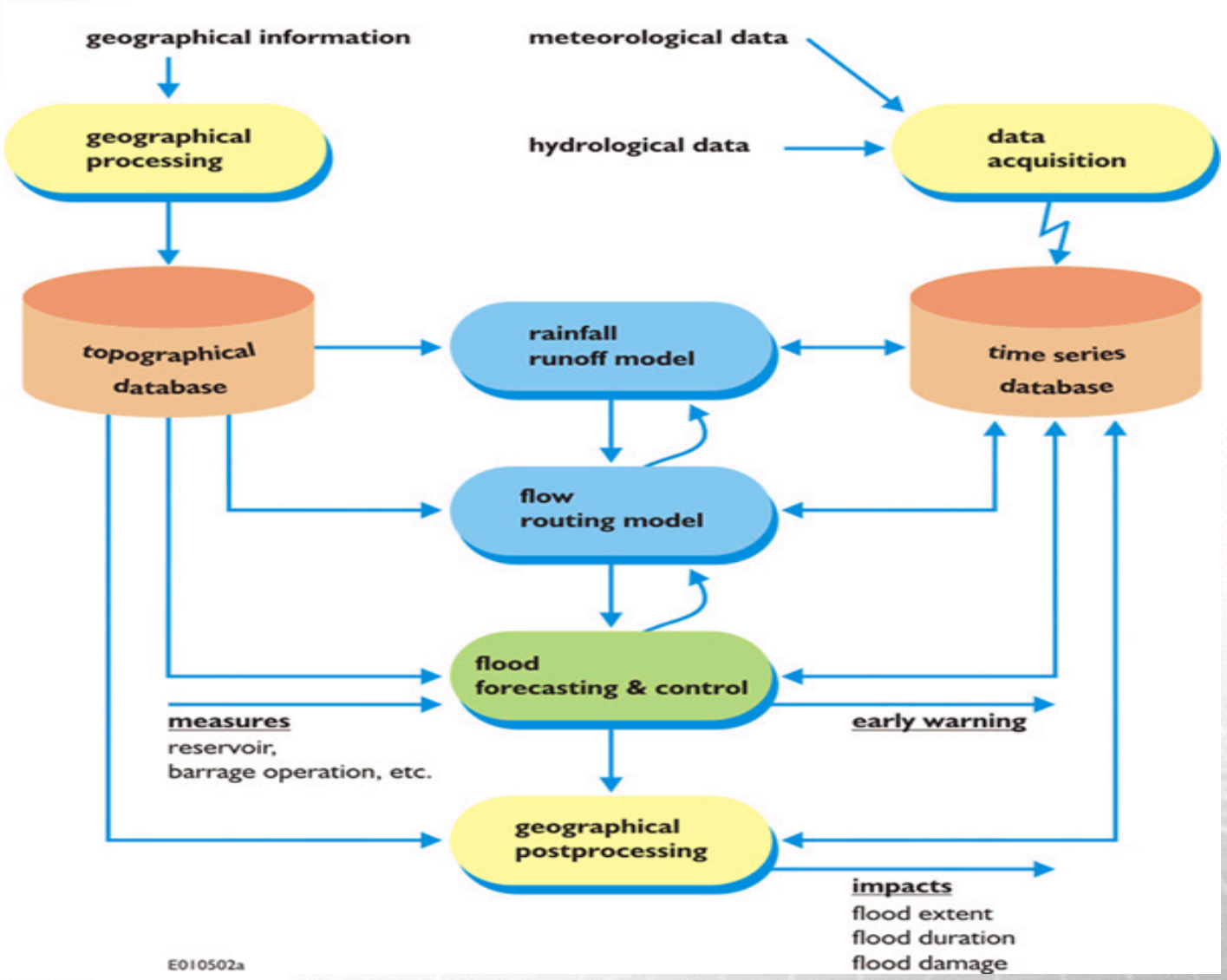
Type of data



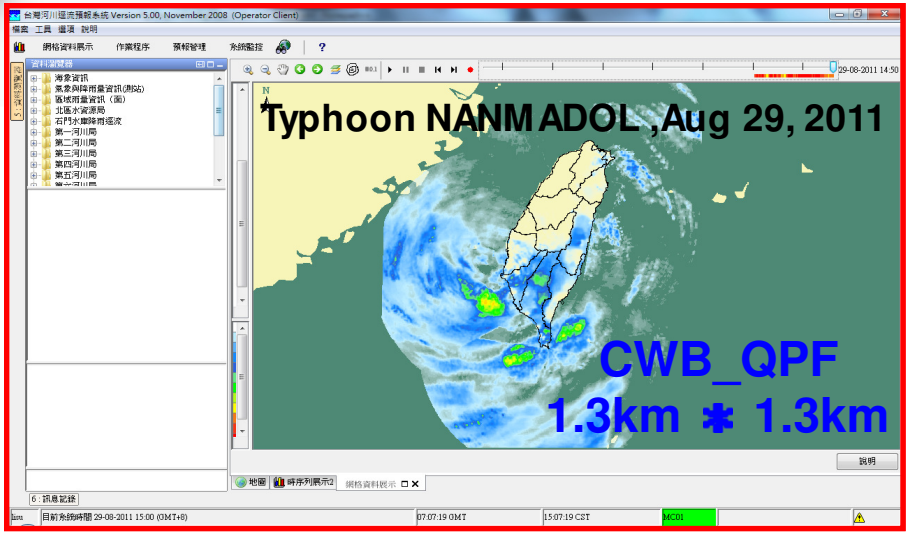
System Architecture

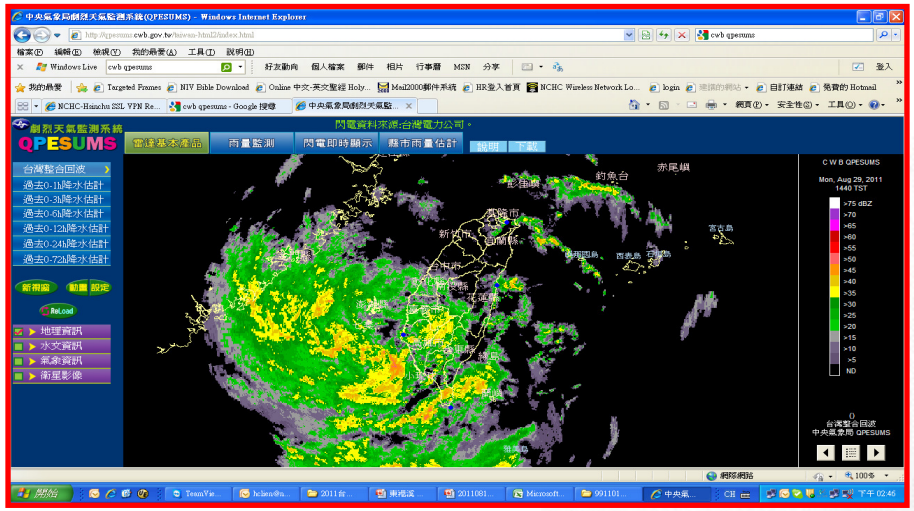


Data Processing Flowchart



Rainfall Forecast

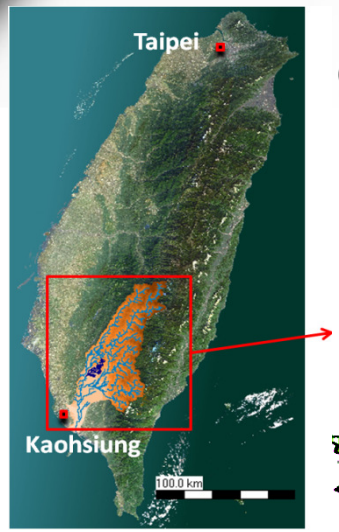




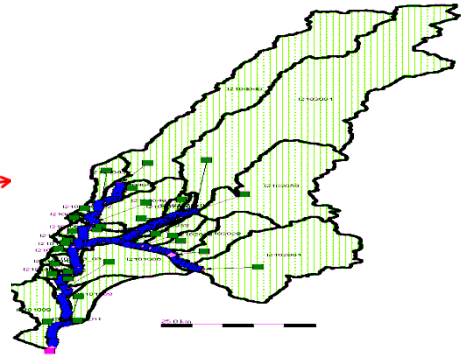
- Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPESUMS) is developed by Central Weather Bureau (CWB) in Taiwan.
- QPF is the rainfall forecast from extending QPESUMS in the lead time of 3 hours .
- FEWS_Taiwan updates the database of QPF from CWB every ten minutes.

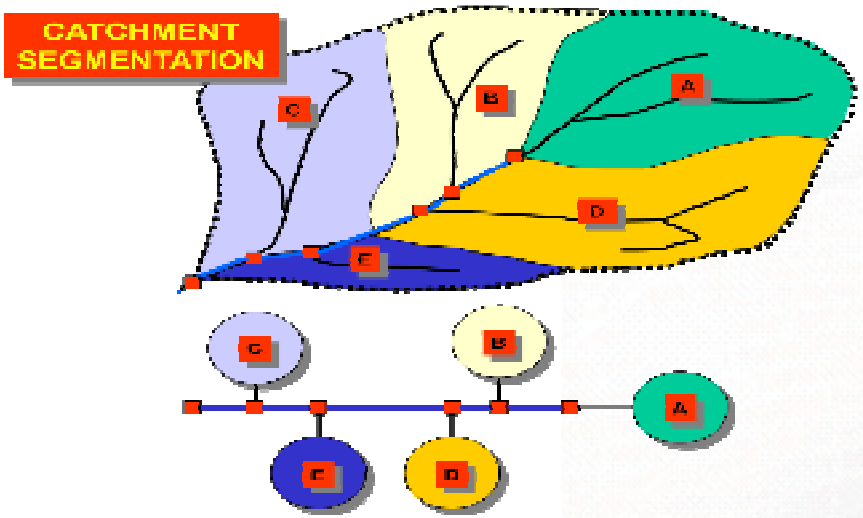
http://qpesums.cwb.gov.tw/taiwan-html2/index.html

Runoff Forecast

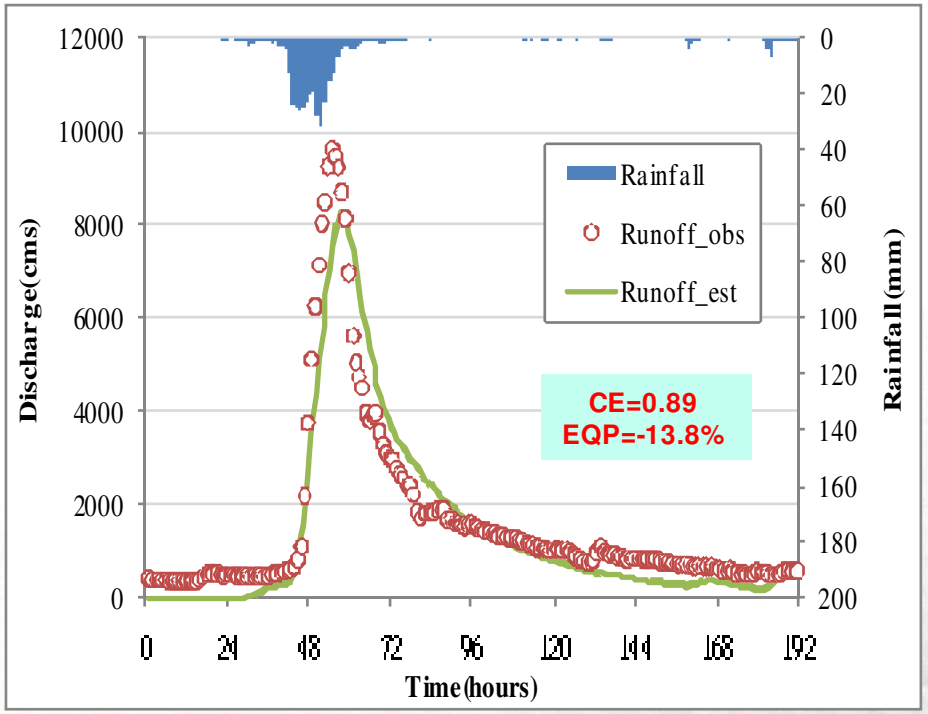


Gaoping River Catchment





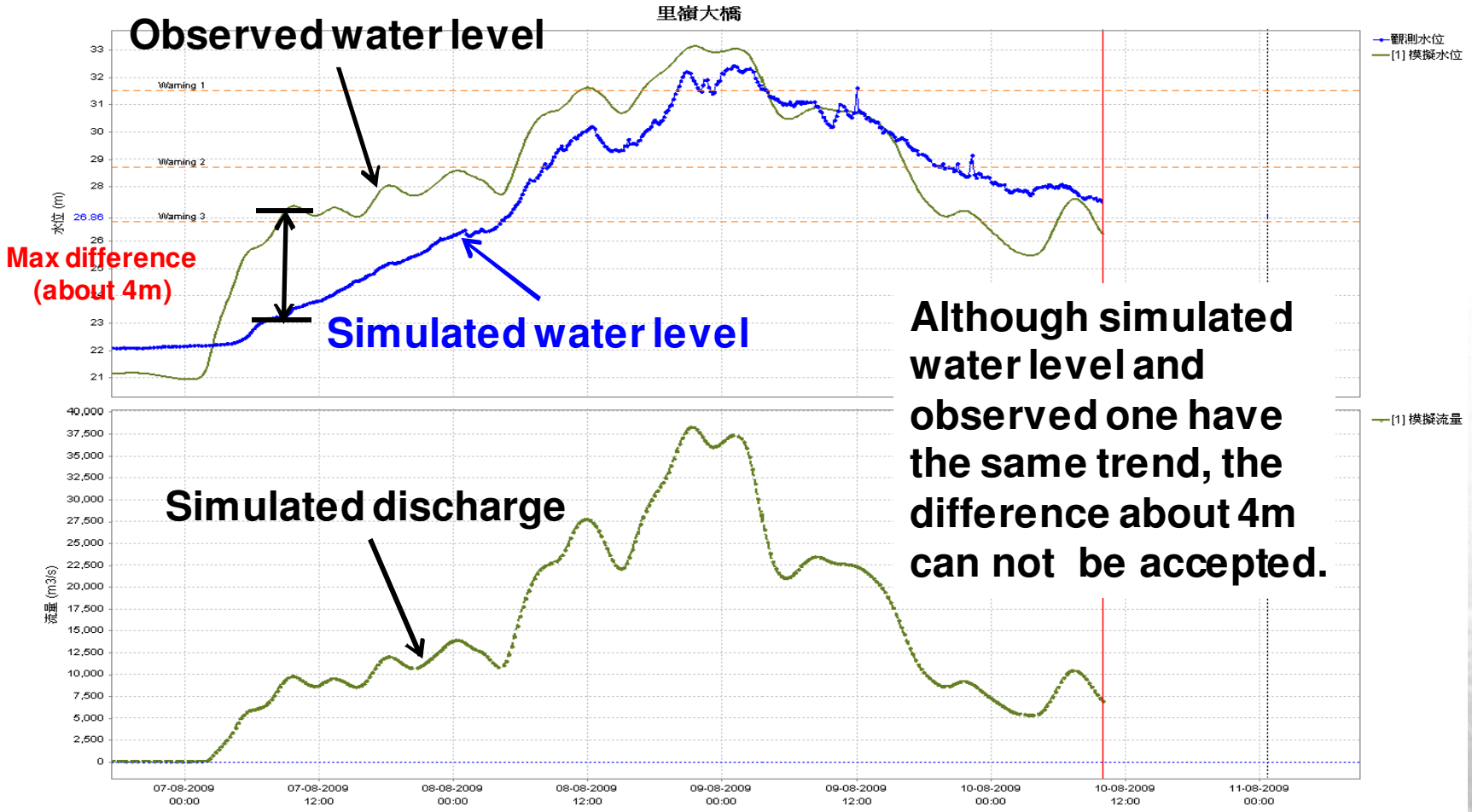
Liling Bridge in Gaoping river
Typhoon JANGMI
(20080927~20081004)



CE= Efficiency coefficient
EQP=Error of peak discharge

Water level Forecast

Typhoon Morakot（2009/08/07～2009/08/10）

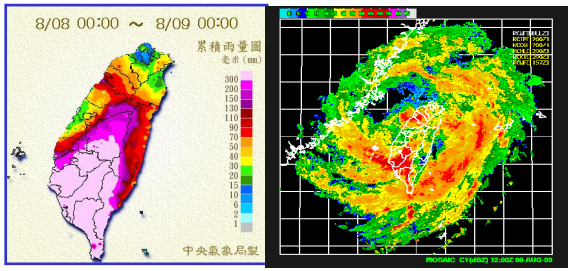


Although simulated water level and observed one have the same trend, the difference about 4m can not be accepted.

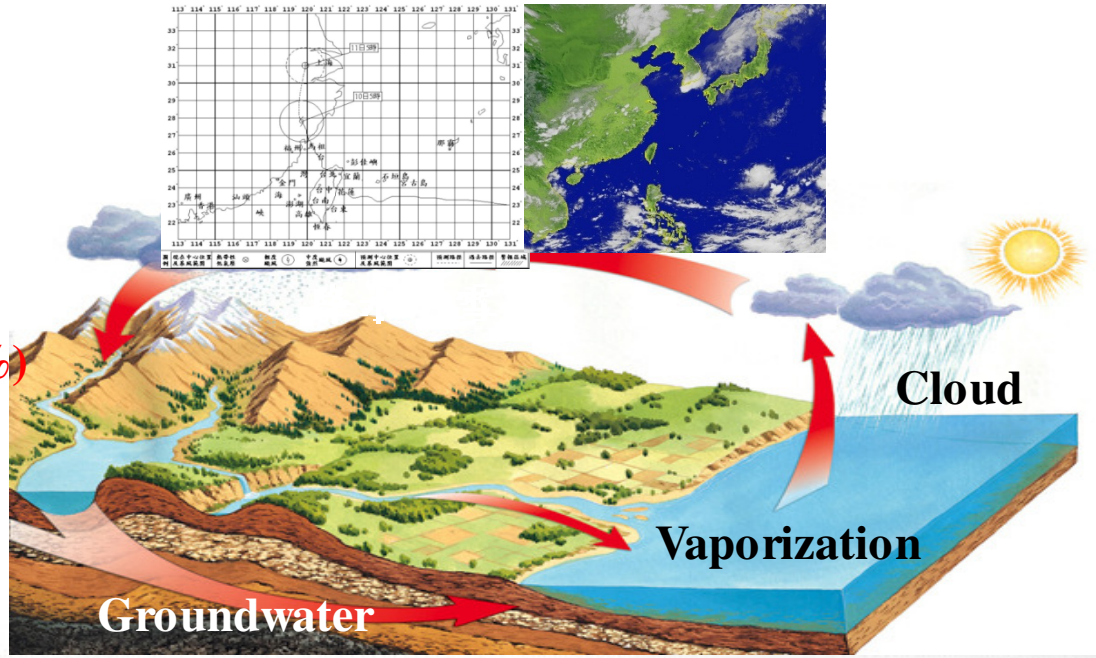
Error Propagation of water level forecast

The accuracy of water level forecasts would be affected by the uncertainties in the precipitation forecast, hydrological and hydraulic modules.

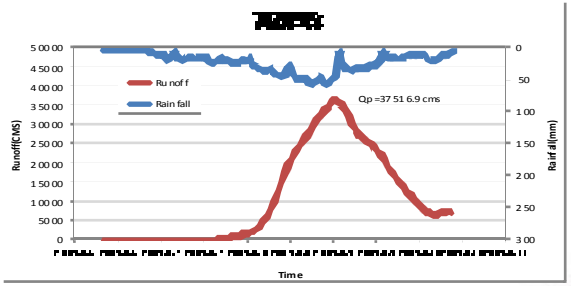
2. Quantitative precipitation forecast (Accuracy=30%)



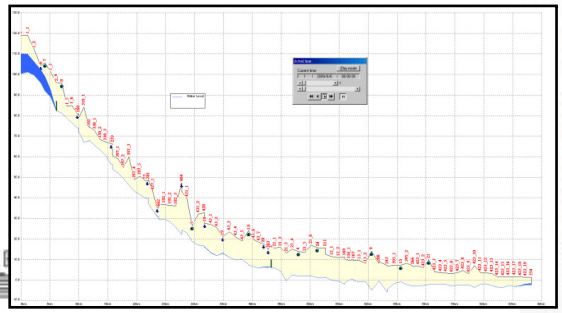
1.Forecast of typhoon track

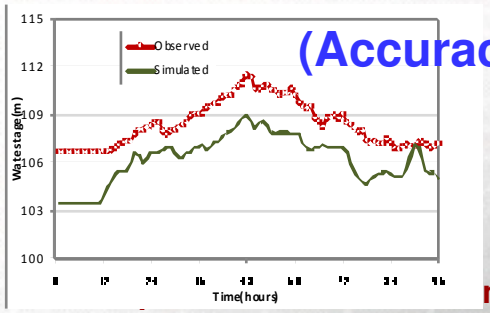


3. Runoff routing (Accuracy =80%)



4. Channel routing (Accuracy =90%)



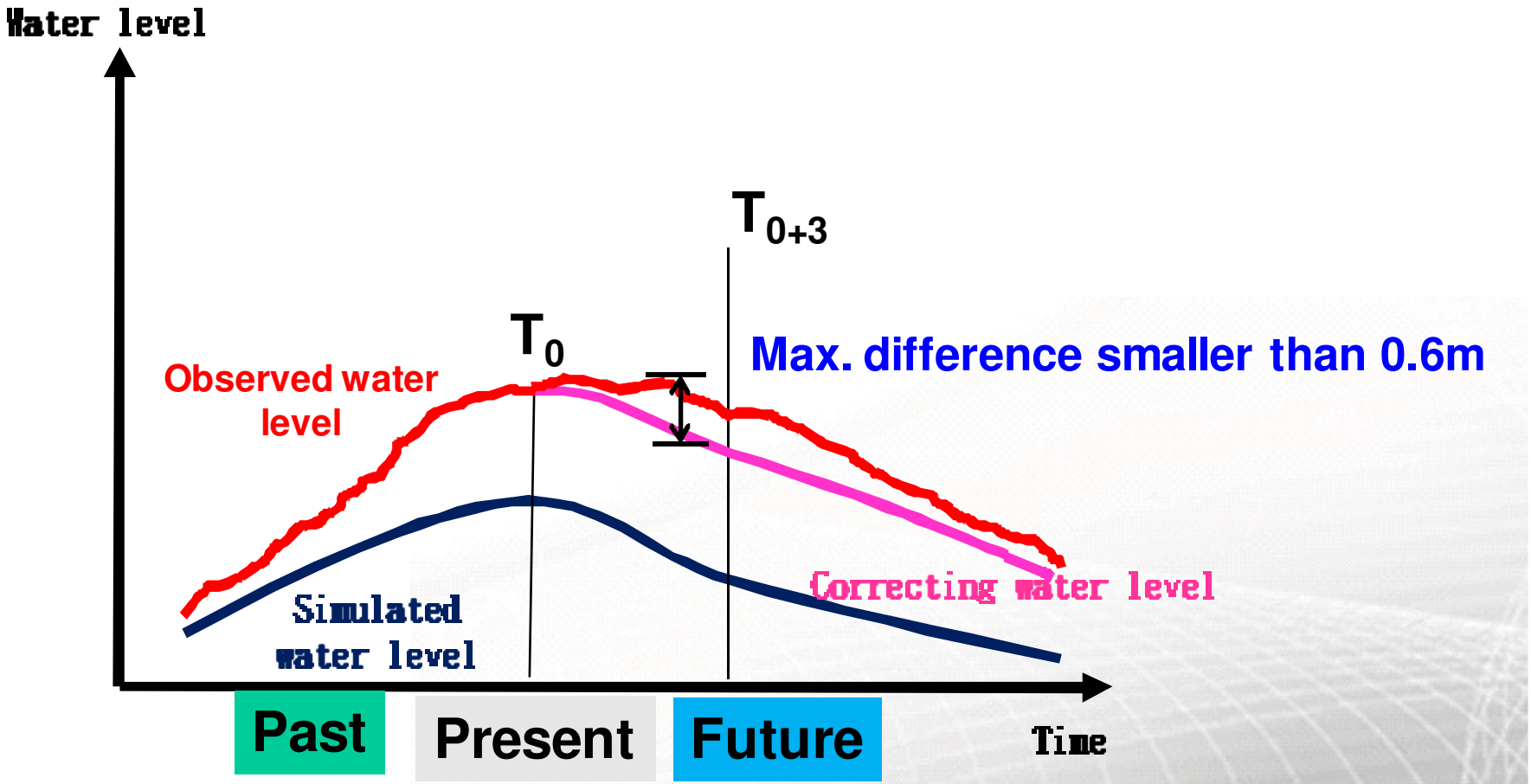


5. Water level forecast

(Accuracy =30%*80%*90%=21.6%)

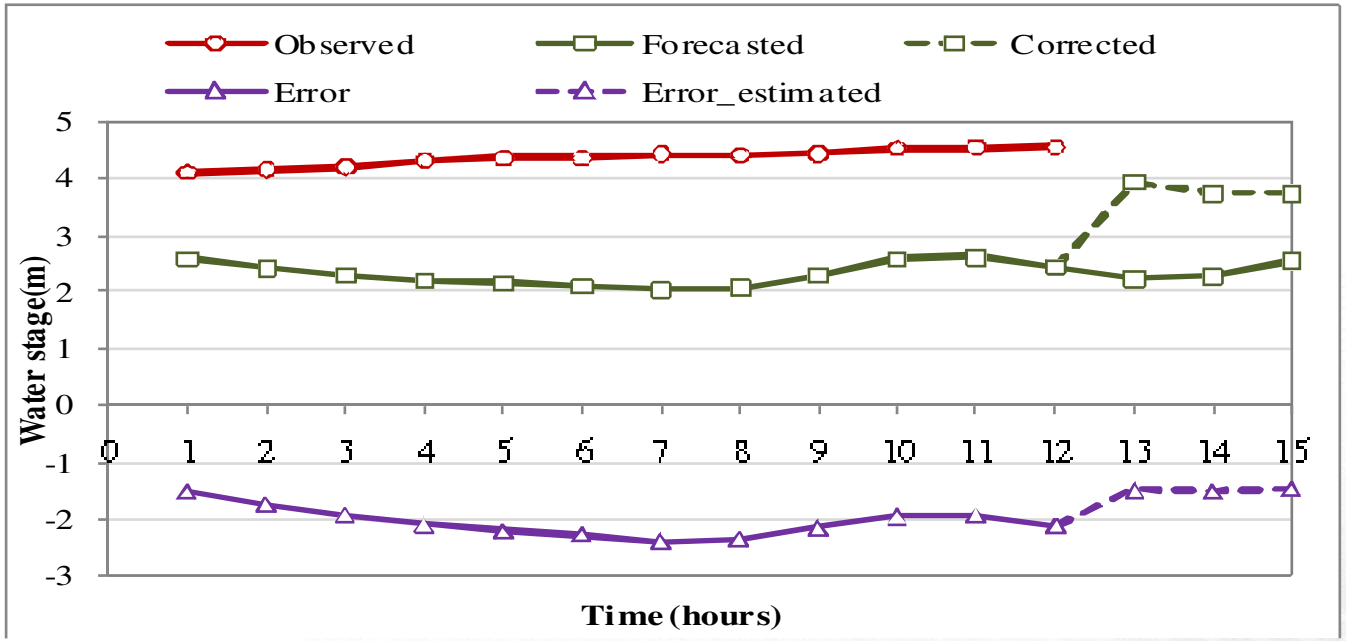
Enhancing accuracy and reliability by means of real-time correction method

Concept of real-time correction



Introduction to real-time correction method for water level forecast

- **Purpose**
  - Reduce the error of water stages forecasted by FEWS_Taiwan attributed to the uncertainties in the precipitation forecast, hydrological and hydraulic modules as well as geographical data of the river.



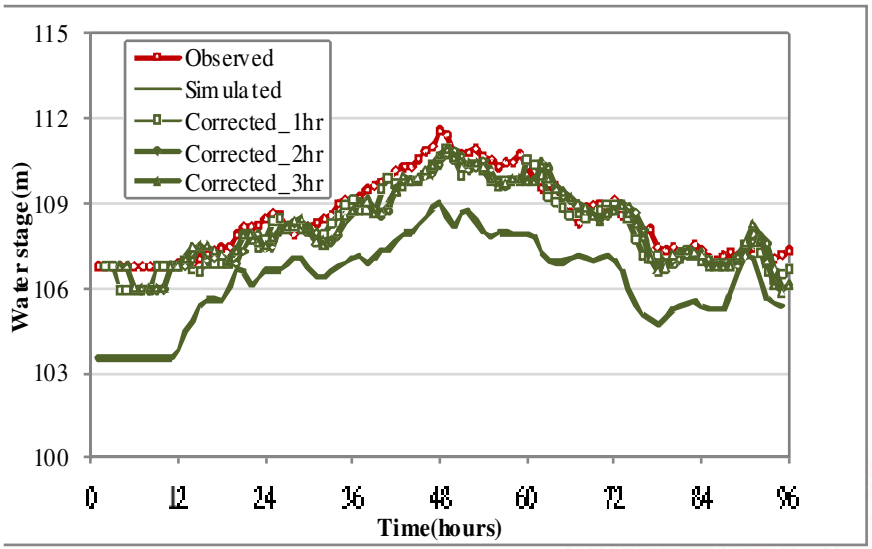
Reference:

Wu. S.J., Lien, H.C., Chang, C.H., and Shen, J.C., 2011. Real-Time Correction of Water Stage Forecast during Rainstorm Events Using Combination of Forecast Errors. *Stochastic Environment Research and Risk Assessment*, Vol. 26, No. 4, pp. 519-531 (SCI) (IF=1.78)

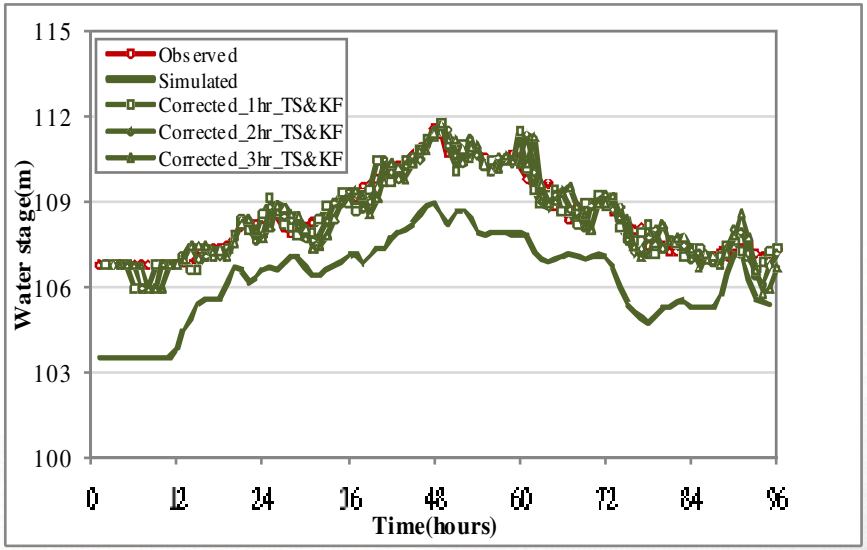
Model Validation

Model validation is made by comparing observed, forecasted and corrected water level at San-Ti-Men gauge in Gaoping River during Typhoon Morakot

Use time series model (TS)

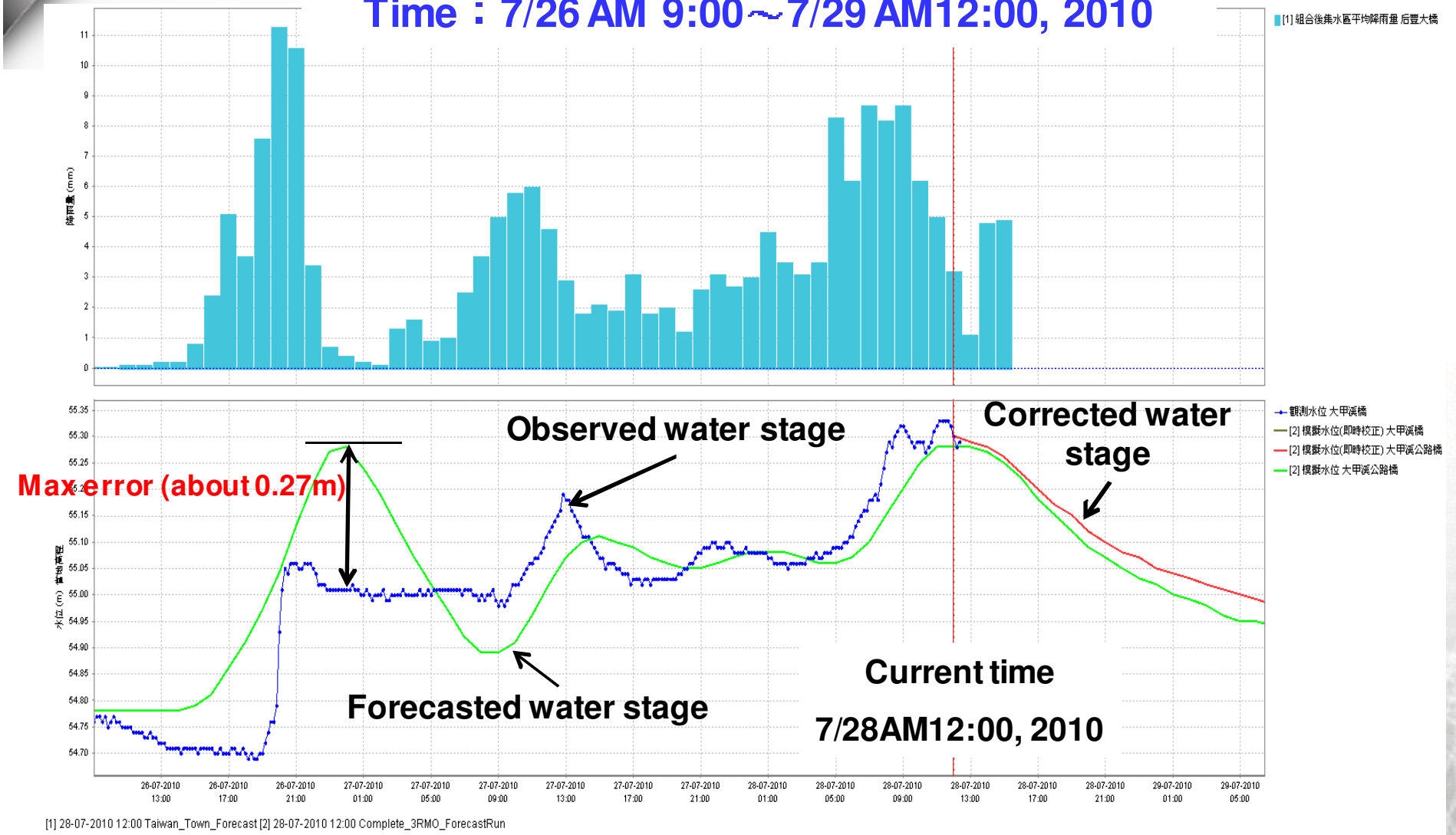


Use time series models and Kaloman filtering method (TS&KF)



- TS and TS&KF method can effectively reduce the errors of the forecasted water levels.
- Average errors of the corrected water levels by TS&KF method is significantly less than those by TS method, in which and the corresponding reduction ratio is 89%.

Comparison of observed, forecasted and corrected water stage at Shih-Kang Dam



Performance of water level forecast during Typhoon Morakot for the 2nd River Management Office of WRA

表 5-10 水位站水位預報與實際水位差一覽表

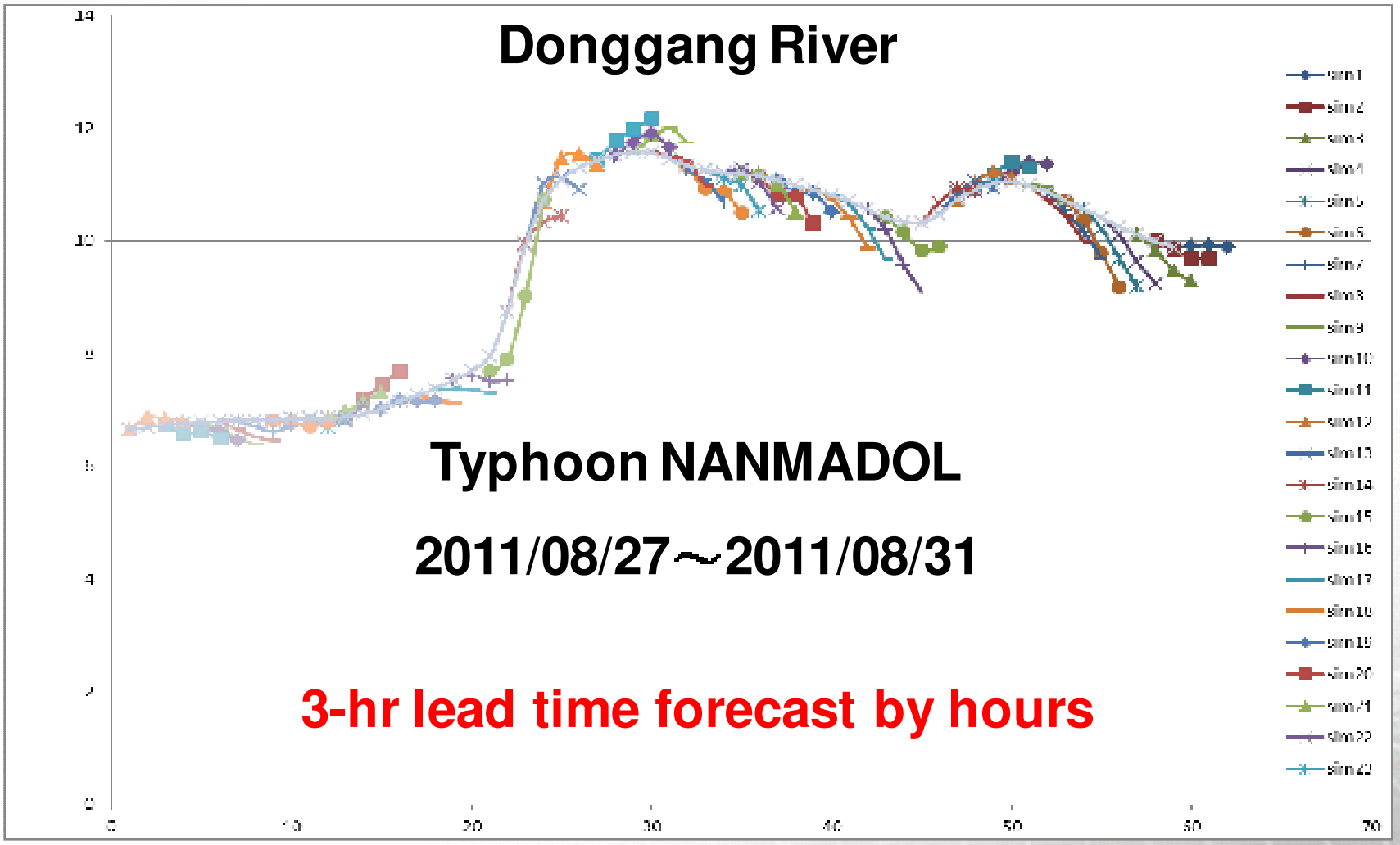
區域	中央管河川	測站	水位預報與實際差(m)(平均)	
二河局	鳳山溪	新埔(1)	1小時	0.21
			2小時	0.38
			3小時	0.57909
二河局	頭前溪	上坪	1小時	0.38364
			2小時	0.65818
			3小時	0.69818
二河局	頭前溪	經國橋	1小時	0.13636
			2小時	0.30273
			3小時	0.48364
二河局	中港溪	平安橋	1小時	0.23546
			2小時	0.41091
			3小時	0.57546
二河局	中港溪	永興橋	1小時	0.40727
			2小時	0.45727
			3小時	0.46364
二河局	後龍溪	勢大橋左	1小時	0.21909
			2小時	0.48182
			3小時	0.44818
二河局	後龍溪	打鹿坑	1小時	0.35909
			2小時	0.50182
			3小時	0.59727

Average error after correcting at 1-hr lead time= 0.2m

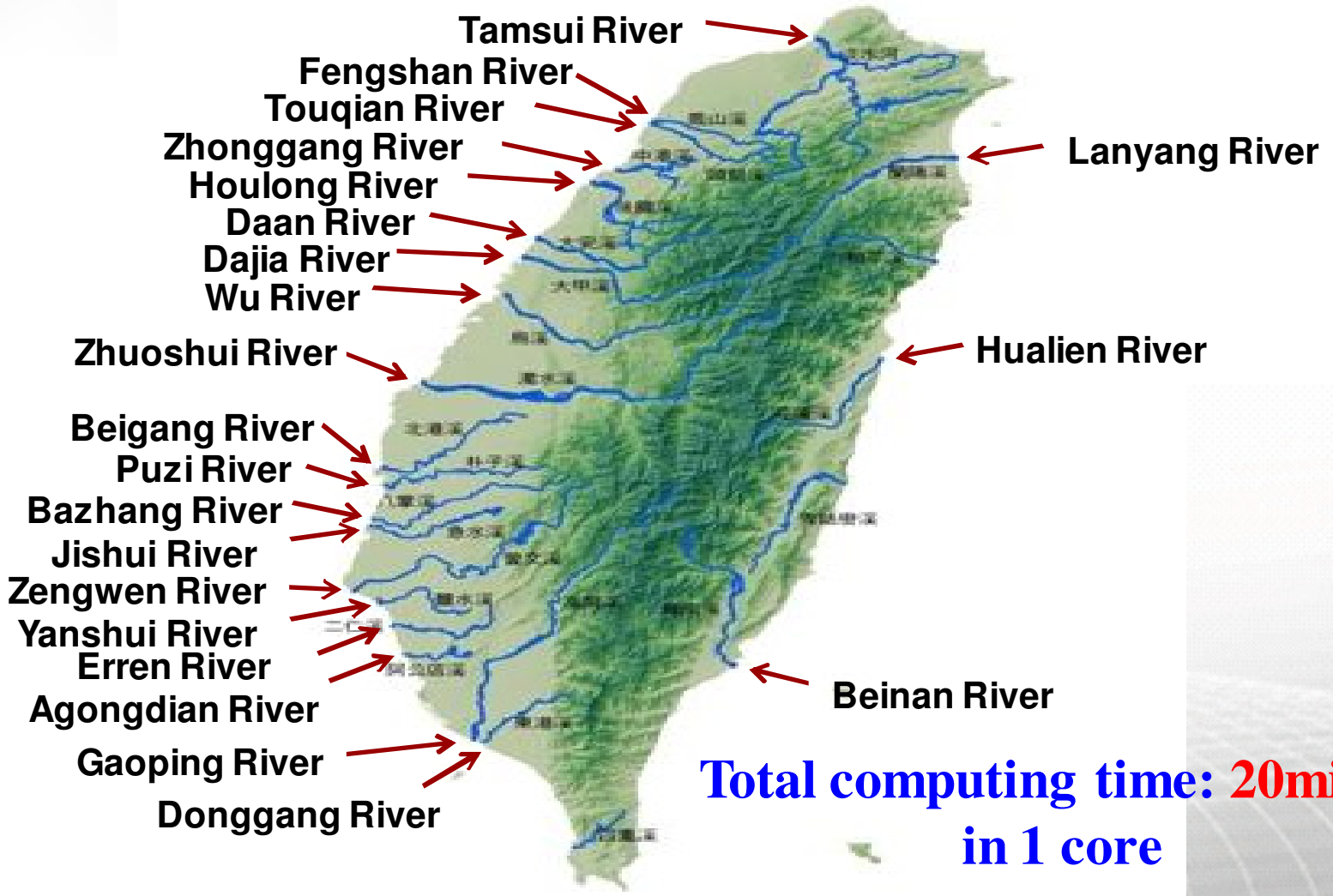
2-hr lead time= 0.4m

3-hr lead time= 0.6m

Water level forecast at Chaozhou stage



23 rivers in FEWS_Taiwan



Total computing time: 20min11s in 1 core

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Flood inundation forecasting (1D/2D simulation)

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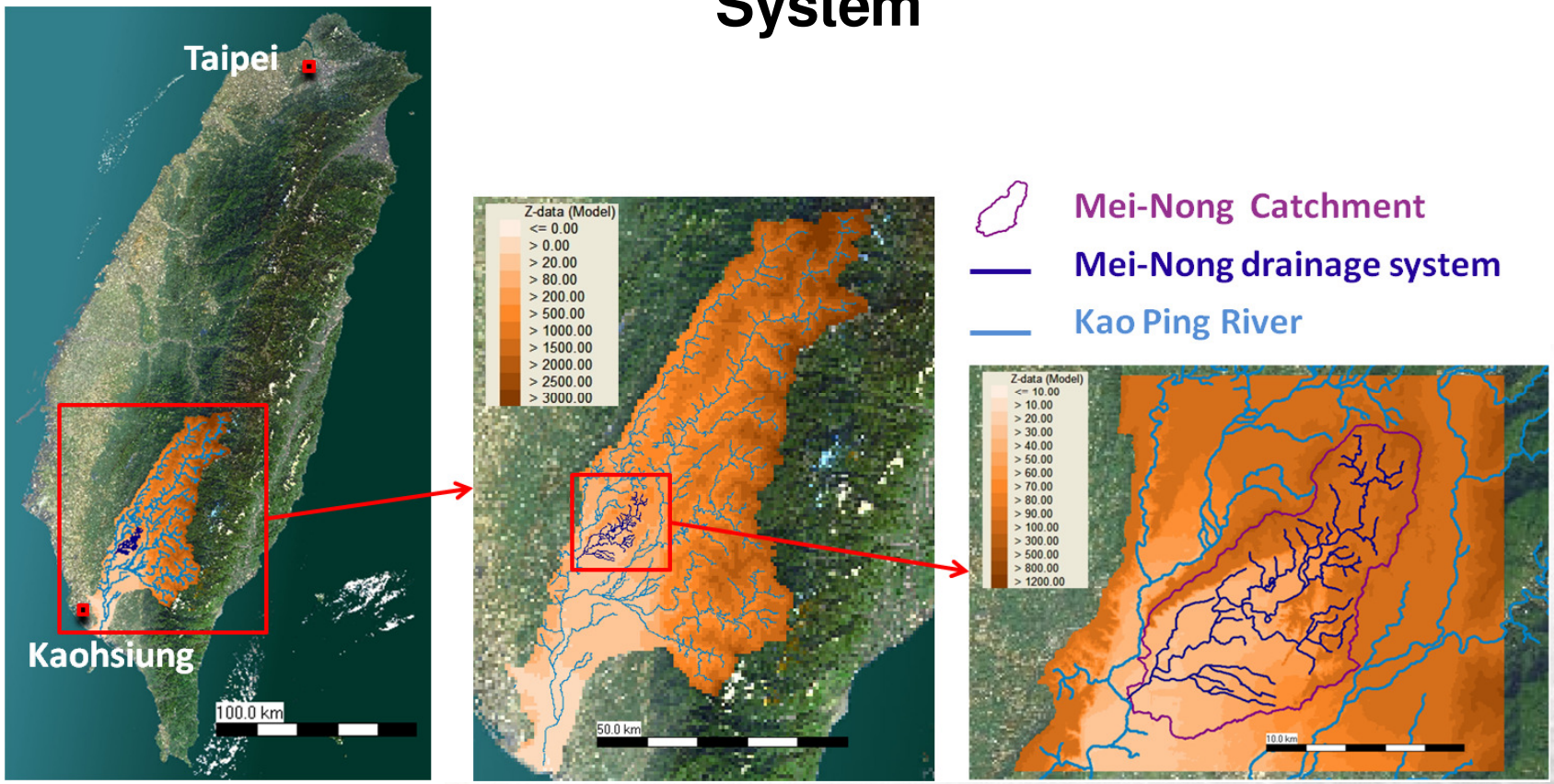
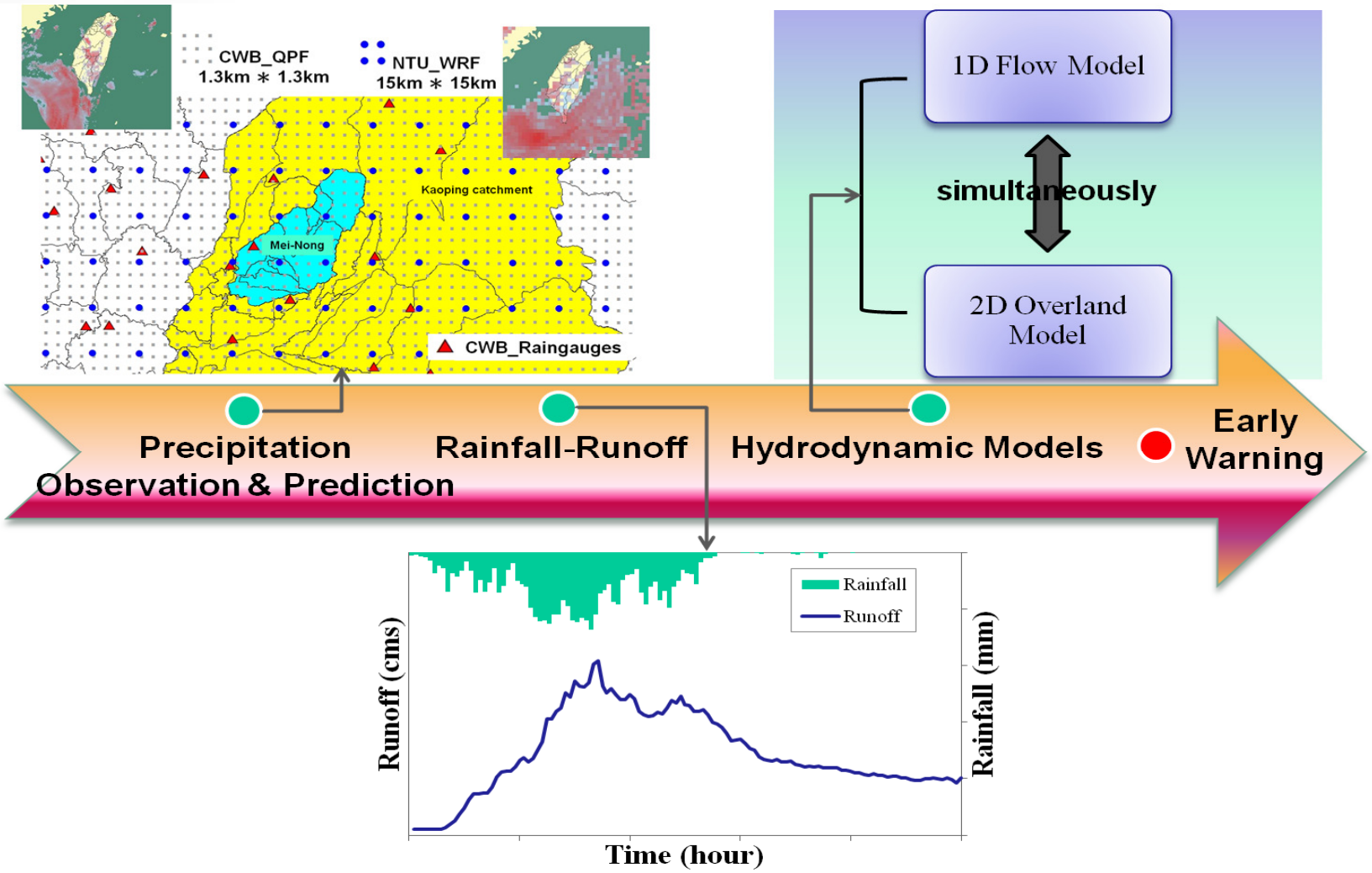
Test Case Study

Koaping River Catchment and Mei-nong Drainage System



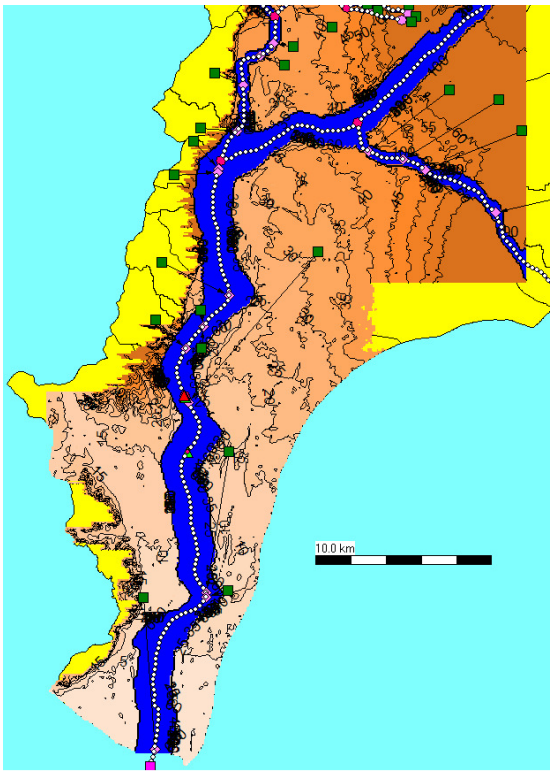
Flood Forecasting Processes

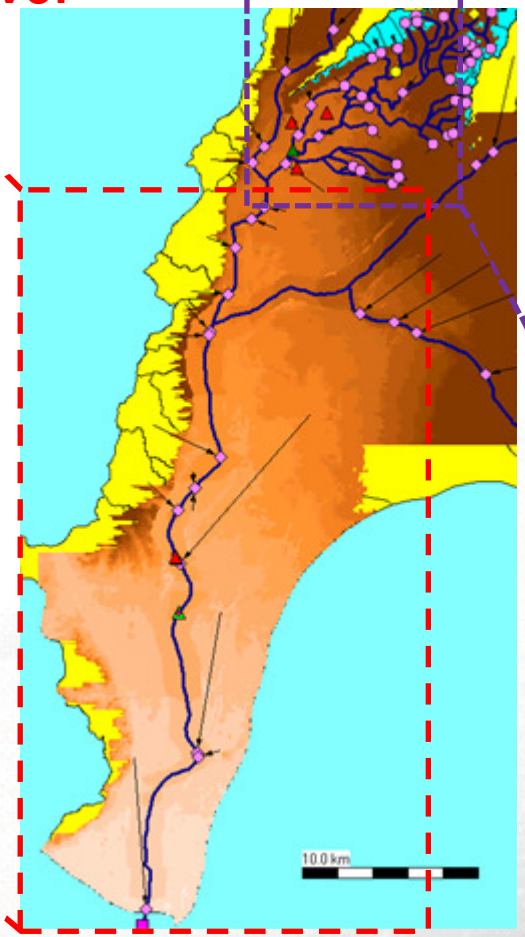


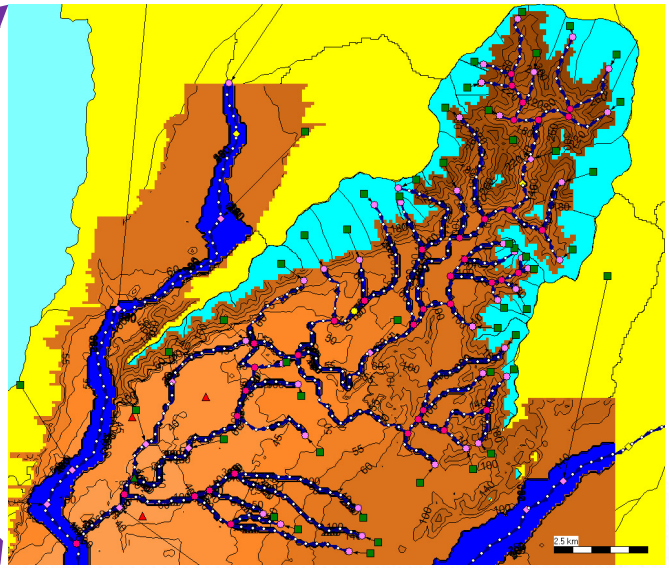
Model Range

Main channel of Kaoping River

171 km





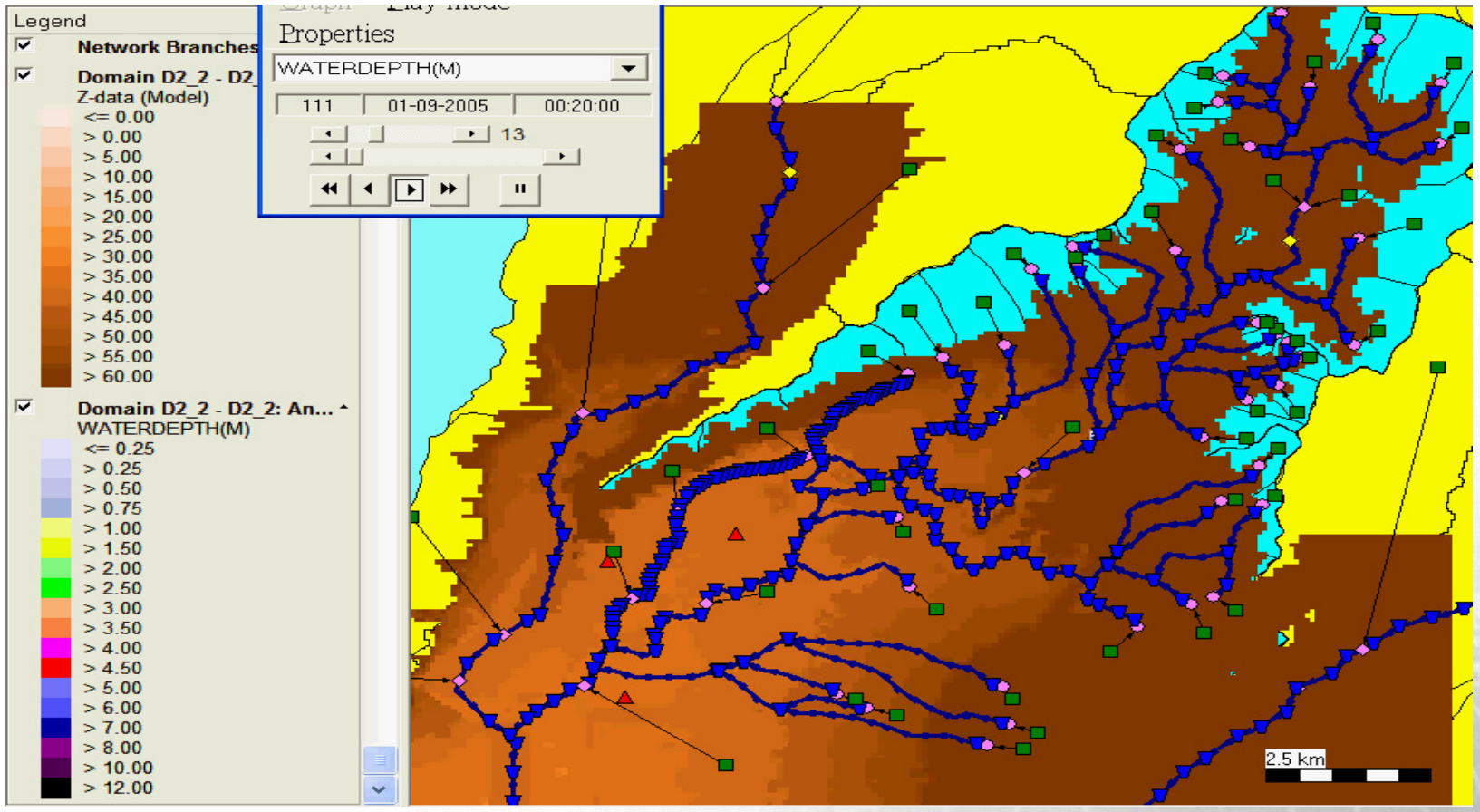


Mei-Nong drainage system

Flood inundation in Mei-Nong drainage

Duration of Typhoon TAILIM: 43hrs

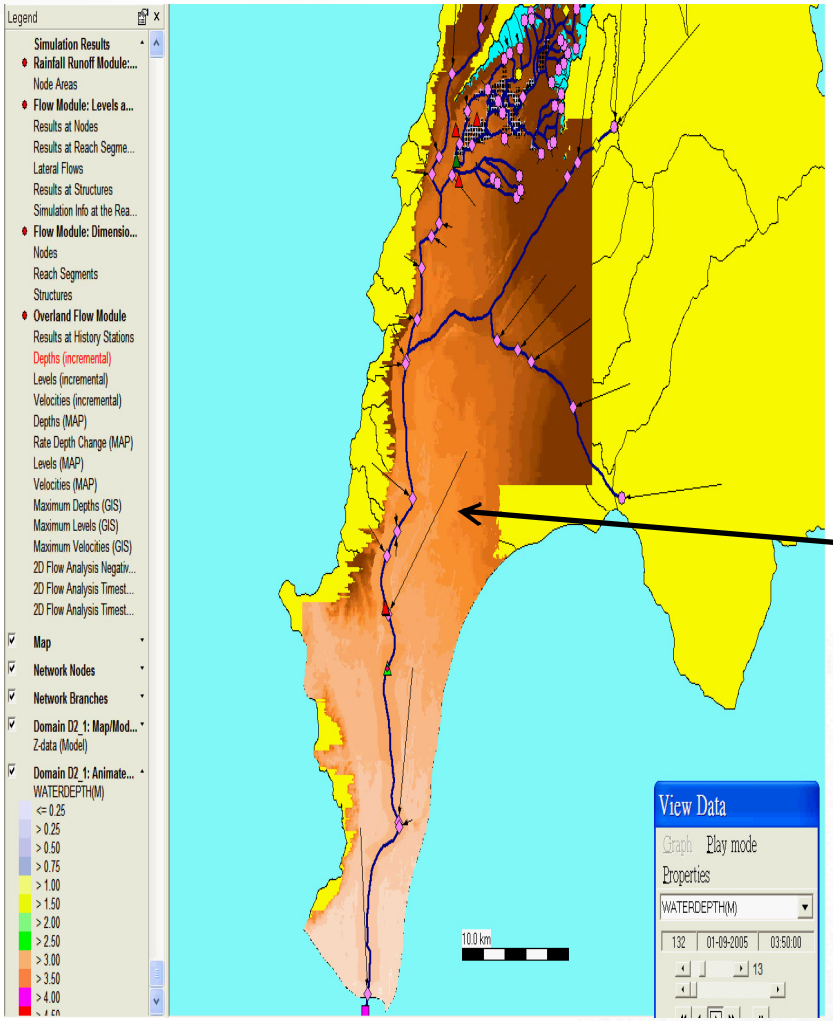
Computing Time	Grid No.
14min37s	67,440

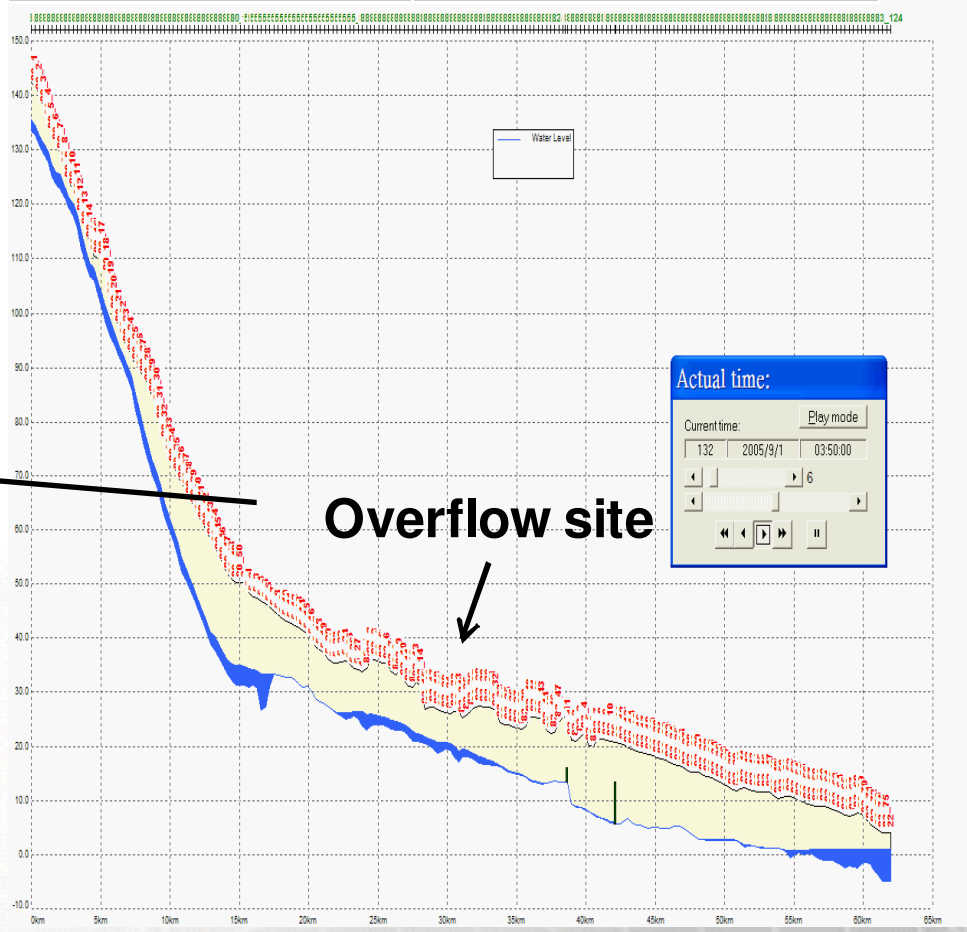


Flood inundation in Kaoping River

Physical Time: 43hrs

Computing Time	Grid No.
44min	152,698

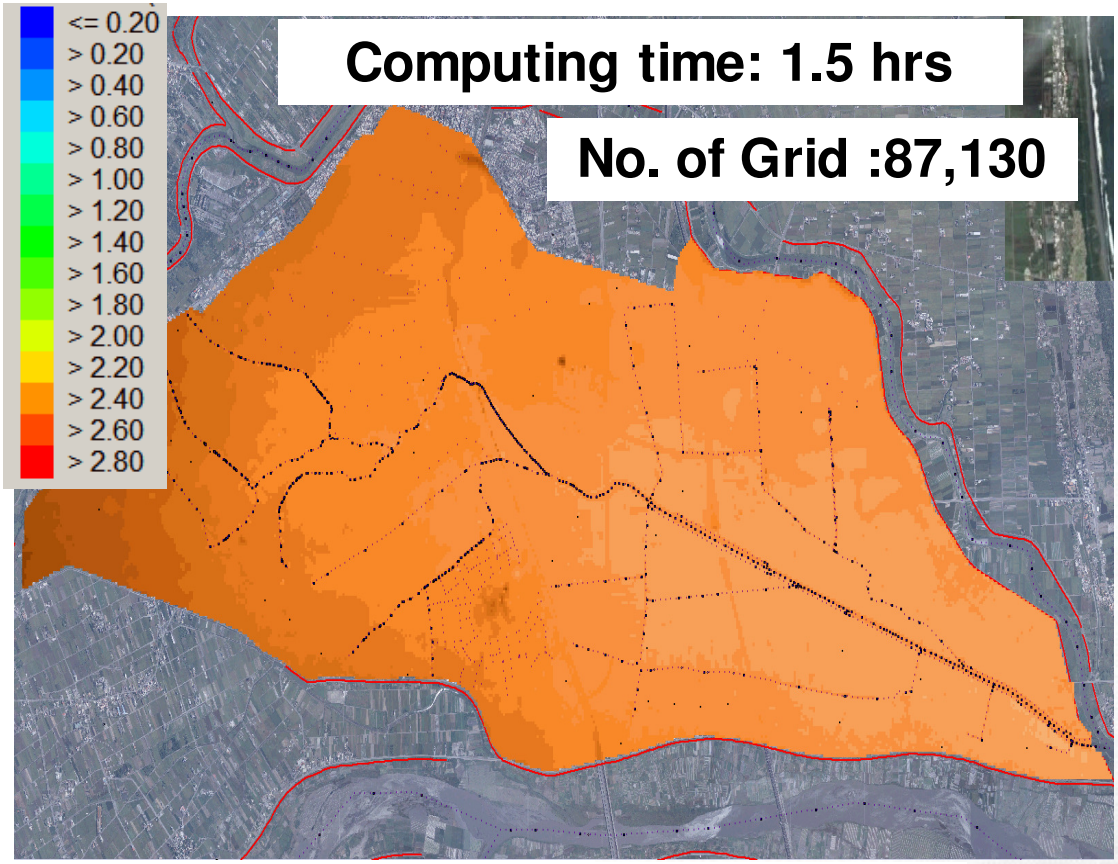


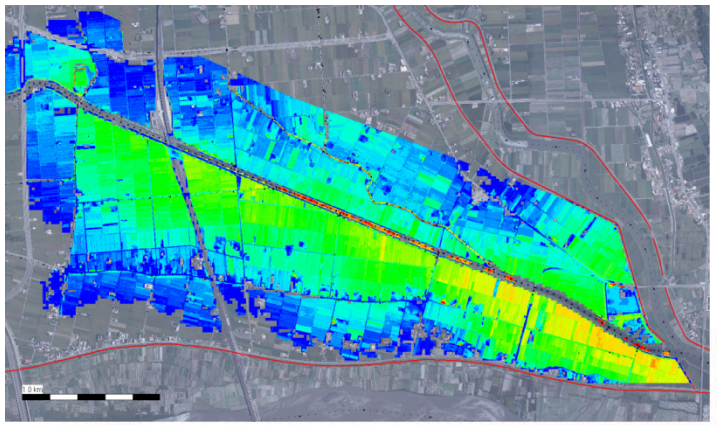


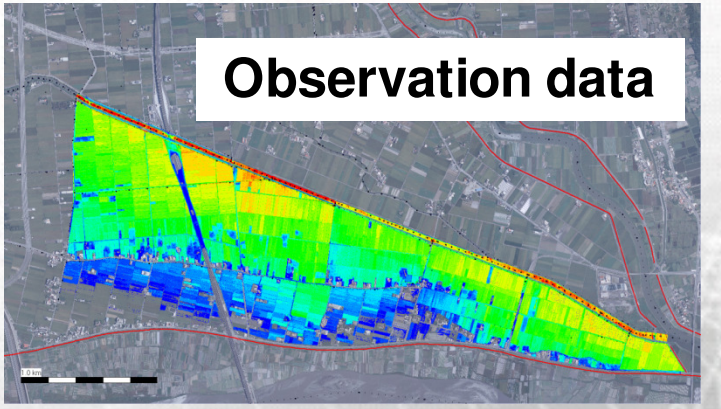
Flood inundation in Mei-fu drainage

Duration of Typhoon SAOLA : 121 hrs
29/07/2012 14:00 ~ 03/08/2012 14:00

Sobek simulation





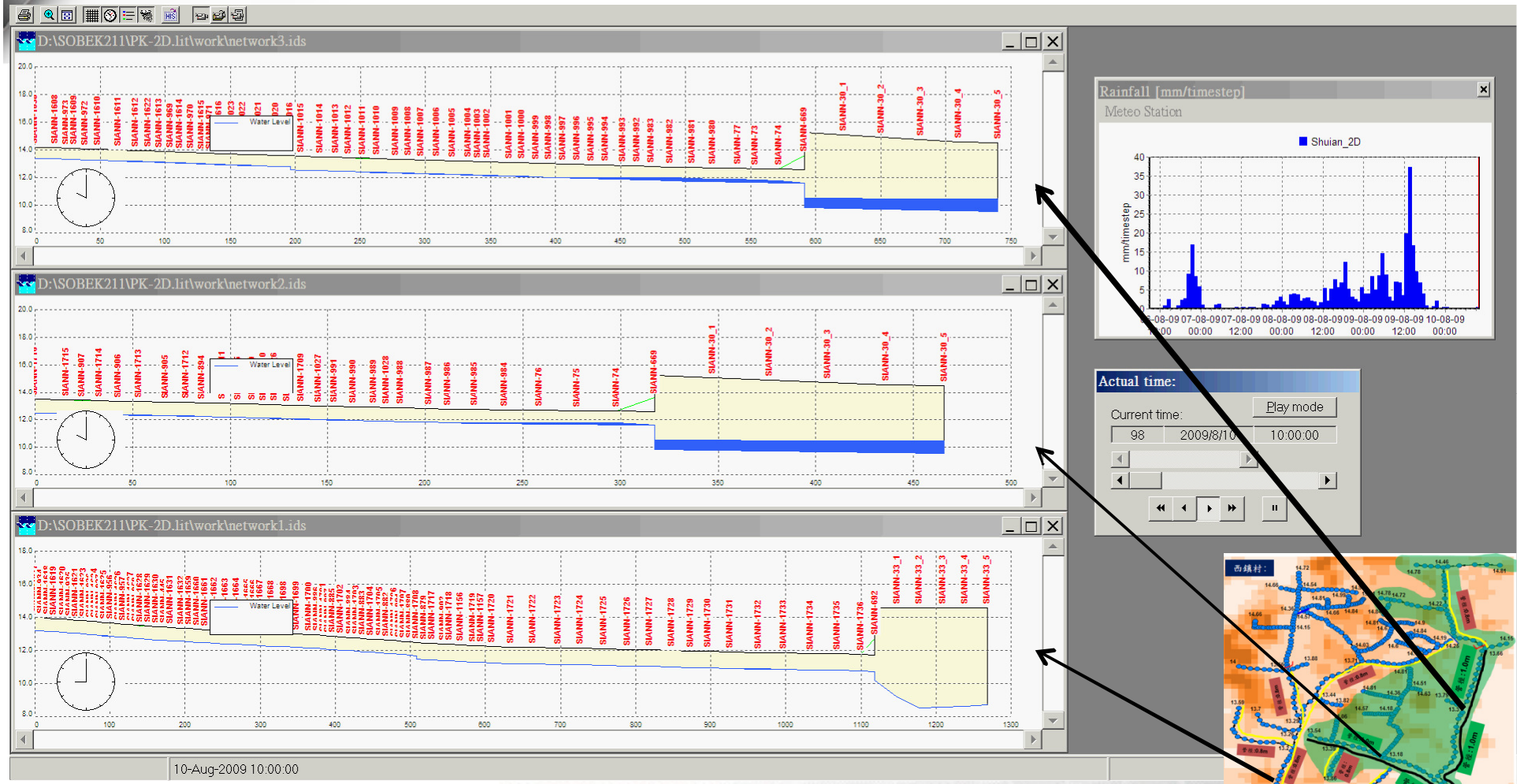


Mei-fu regional drainage area

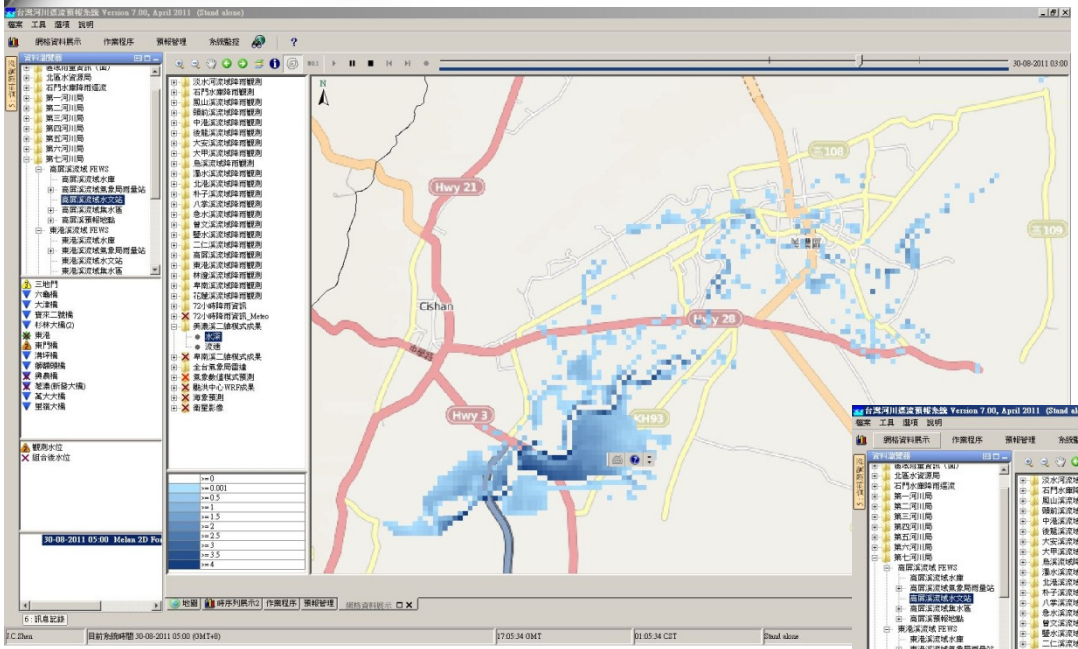
Flood inundation in Hsin-an drainage

Duration of Typhooh MORAKOT : 97 hrs
Computing Time : 2 hrs

Variations of water level in sewerage

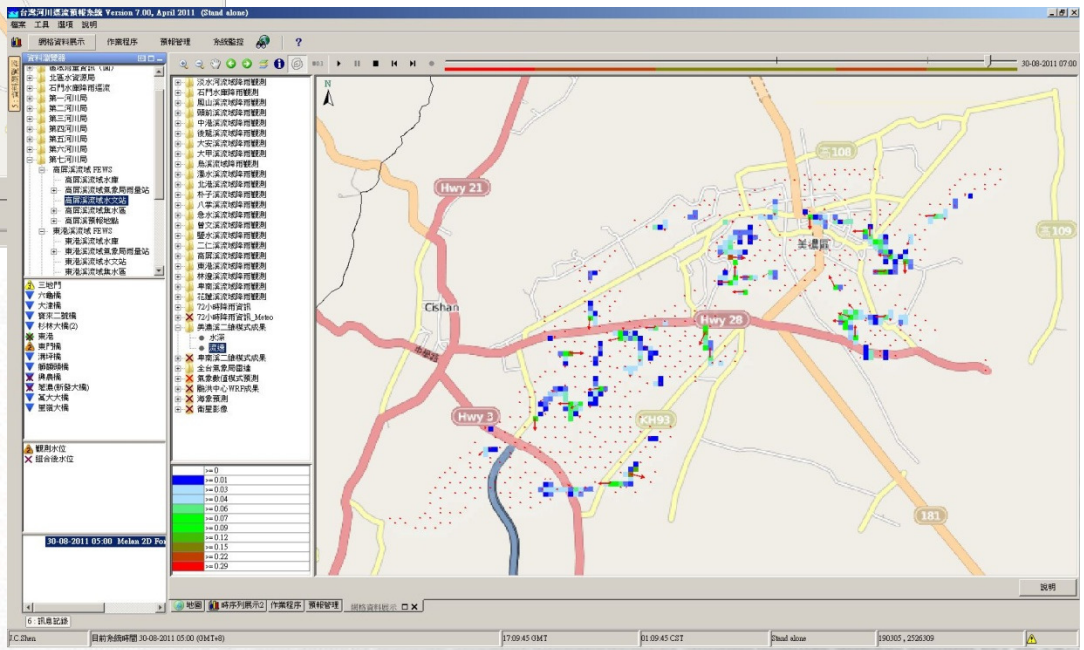


GIS-based display on FEWS_Taiwan



Inundation area & depth

Flood velocity



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Ensemble Water level Forecasting

財團法人國家實驗研究院
國家高速網路與計算中心
NATIONAL CENTER FOR HIGH-PERFORMANCE COMPUTING

Why do we need ensemble prediction?

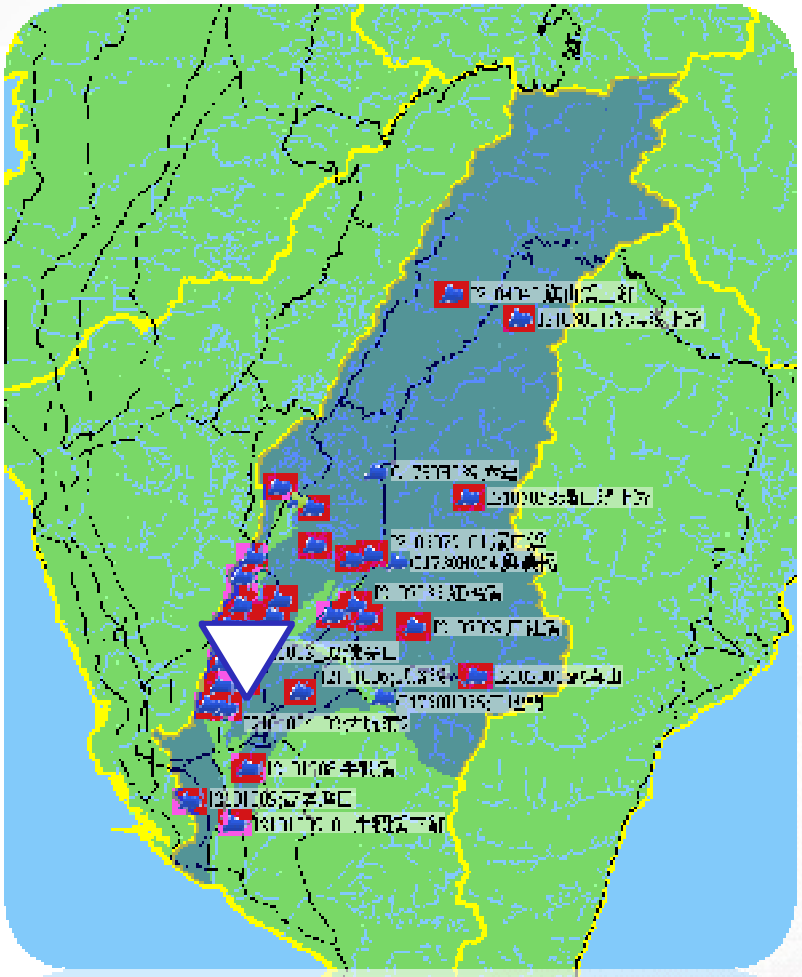
- A “scenario-based” approach
- Flexibility to incorporate
- Provides future water level probabilities.

Ensemble water level Forecasting

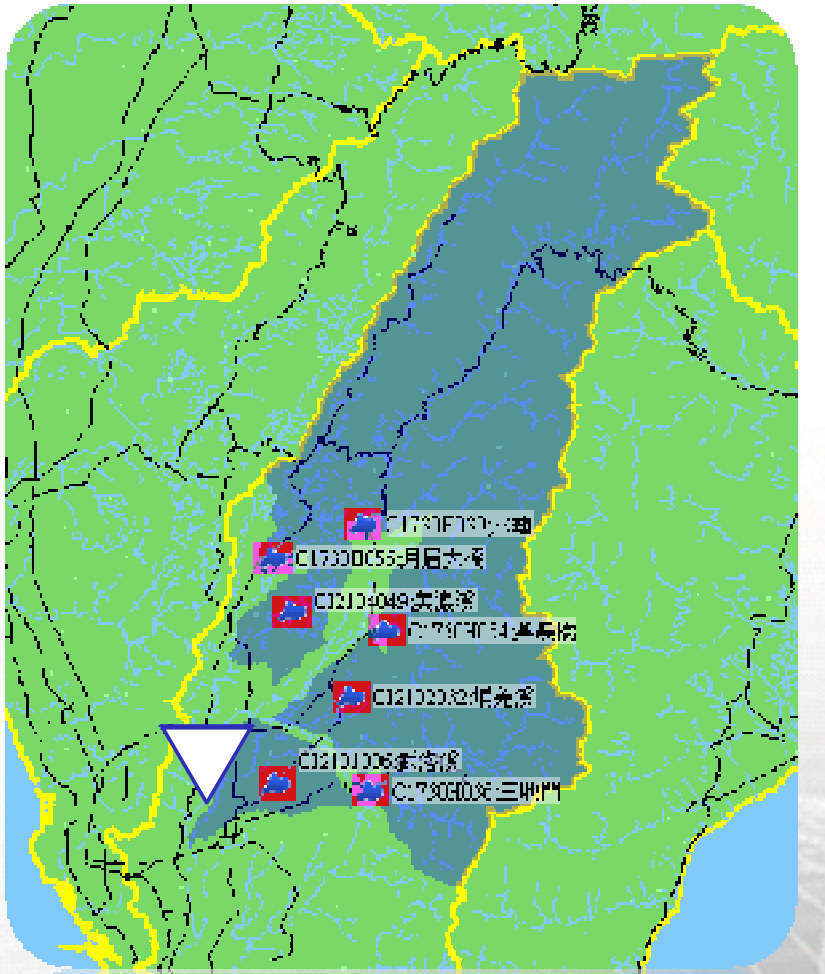
- Sponsor : NSC, WRA
- Conditions
  - Different precipitation models
  - Different runoff models
  - Different divisions of watershed
- System
  - Flood Ensemble Prediction System(FEPS)
- Working group
  - NSC, NCHC, NTUT

Different divisions of watershed

29 Basins

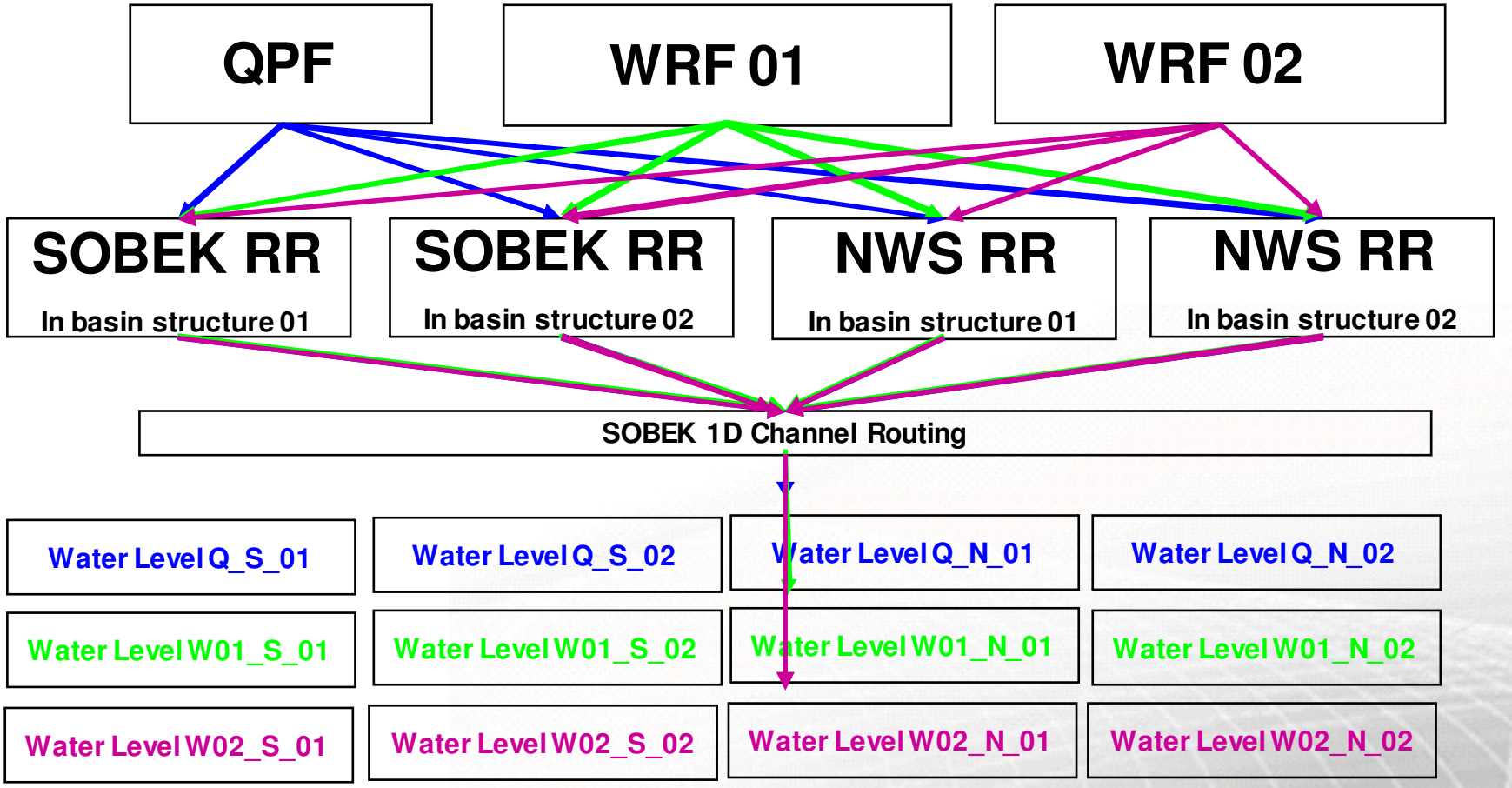


7 Basins

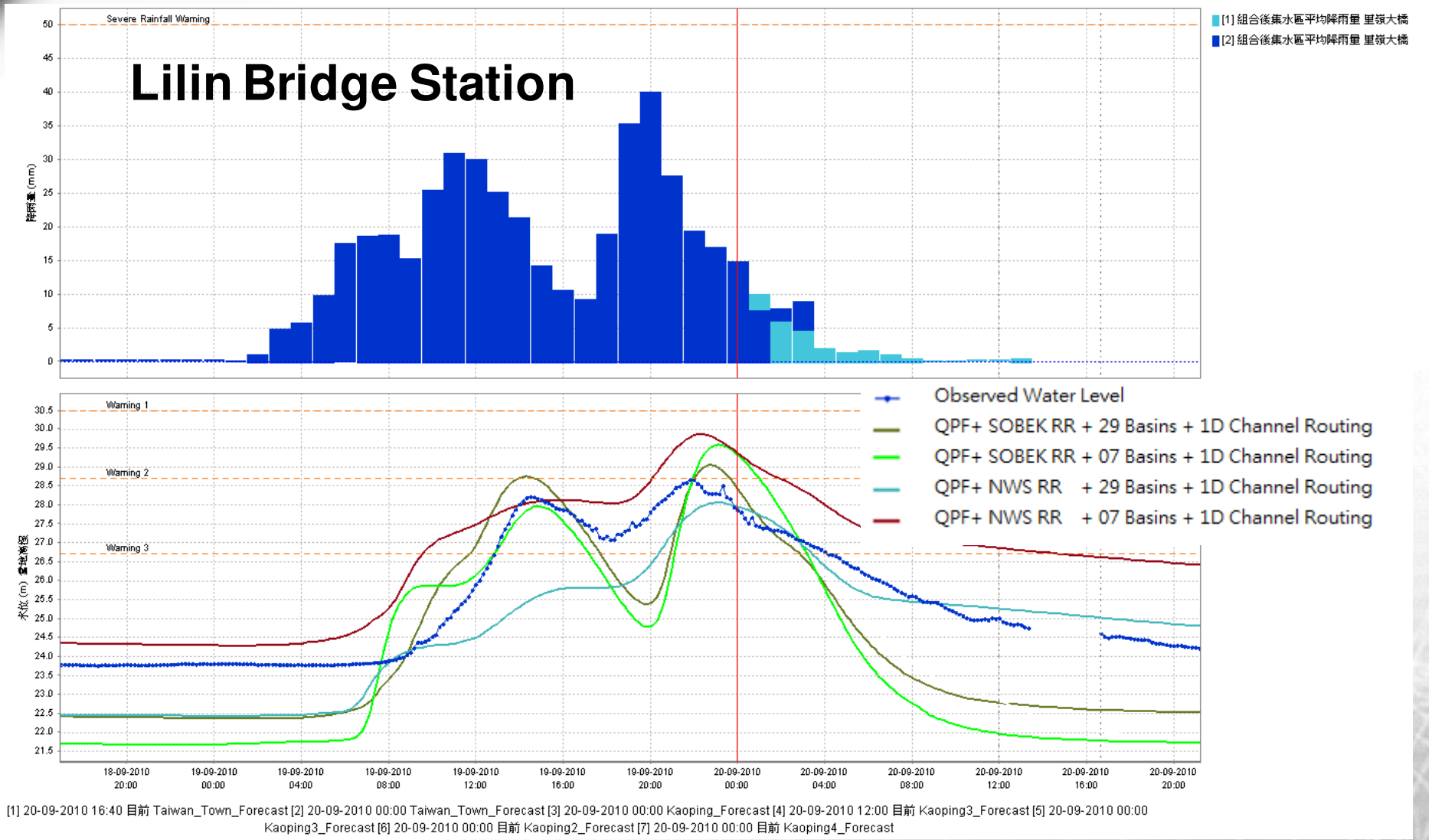


Upstream Basin Structures for Lilin Bridges

Integration of Multi-Data and Models



Ensemble Simulation for Water level



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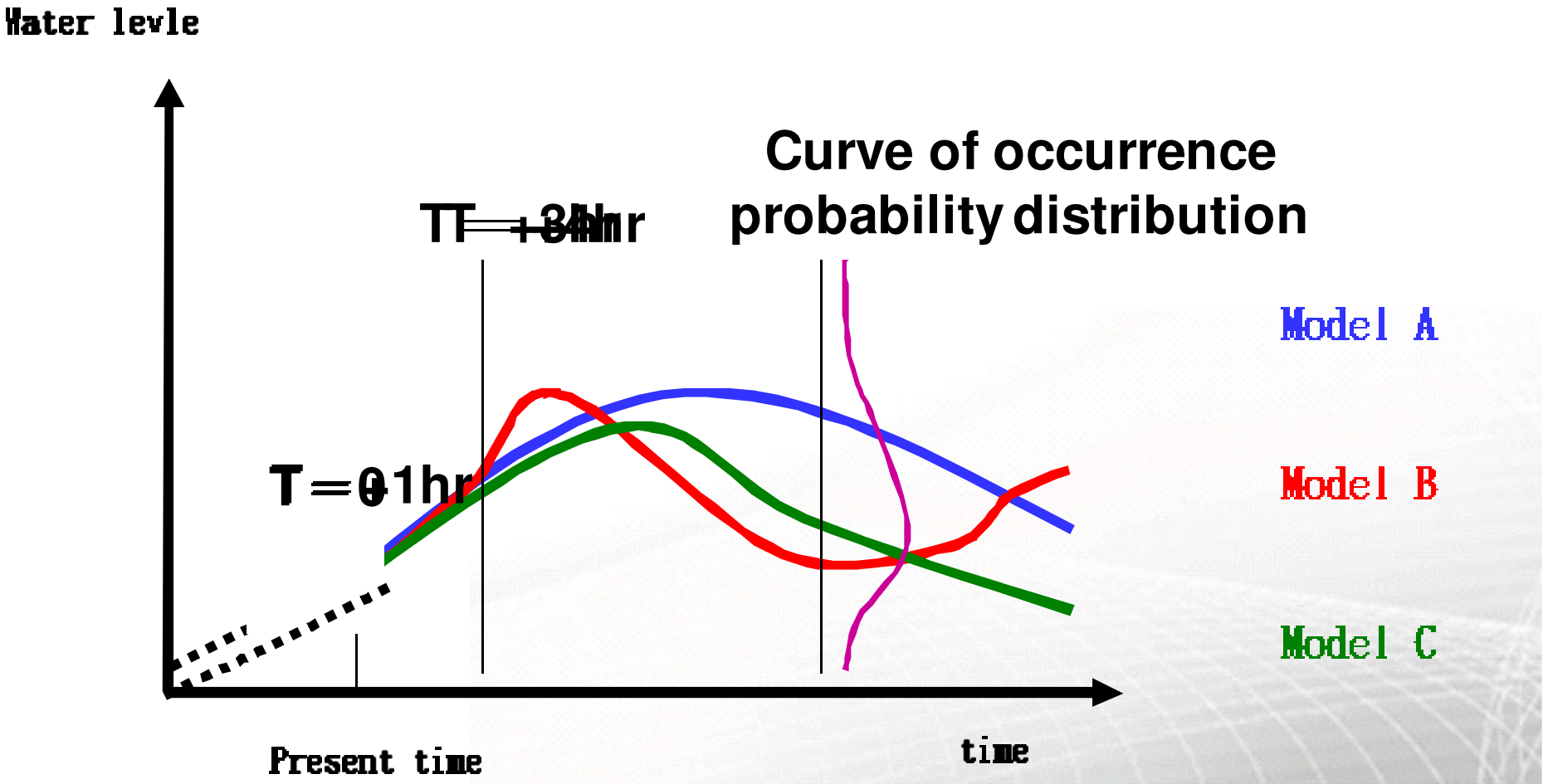
Concept of ensemble water level forecasting



Conlusions

- FEWS_Taiwan has been developed, and it can provide the water level forecasting at 3-hours lead time every hours.
- By analyzing the difference between observed and simulated data at the previous time steps, the proposed real-time correction method is able to enhance the quality of forecast.
- Within FEWS_Taiwan, we have a good opportunity for performing real-time flood inundation simulation. It is a big challenge.
- Ensemble prediction can provide water level probability.

Thank you
for your kind attention