# 2020 International Smart Cities e-Forum

# 智慧城市國際線上論壇

# 都會區即時淹水預報之構想

## Conception of Real-time Flood Forecast in Metropolitan Area

# 台灣淹水潛勢圖發展
# Development of Flood Hazard Mapping in Taiwan

**2000**

「災害防救法」第22條第7款規定進行災害潛勢、危險度及境況模擬之調查分析，並適時公布其結果

Disaster Prevention and Protection Act

**1999~2001**

國家災害防救科技中心(NCDR)完成全省淹水潛勢圖(第一代)

1st Generation Flood Hazard Mapping by NCDR

**2007**

水利署進行全國淹水潛勢圖更新(第一次更新) (第二代)

2nd Generation Flood Hazard Mapping by WRA

**2013**

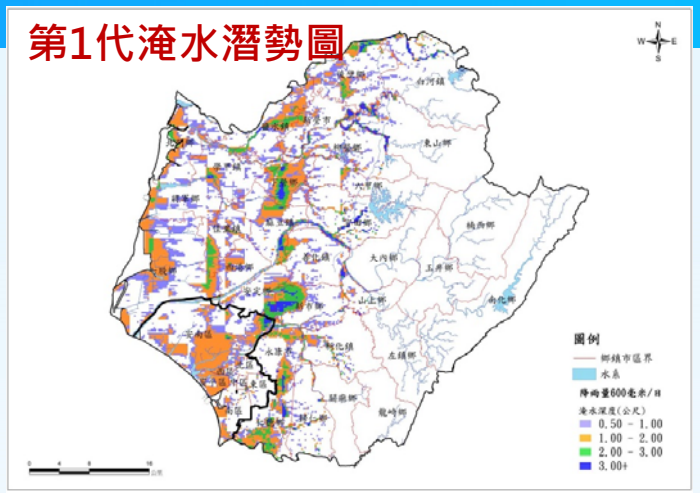
水利署制訂「淹水潛勢圖製作及測試手冊」，研擬標準作業程序

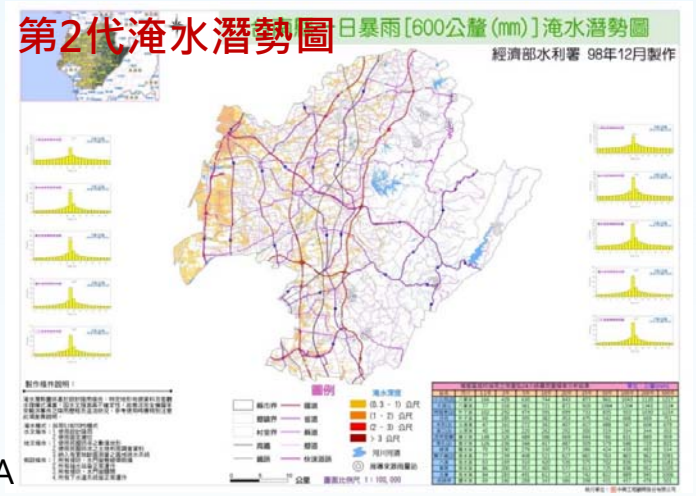
Handbook for 3th Generation Flood Hazard Mapping by WRA

**2014~2016**

完成全台淹水潛勢圖第二次更新(第三代)

3th Generation Flood Hazard Mapping by WRA



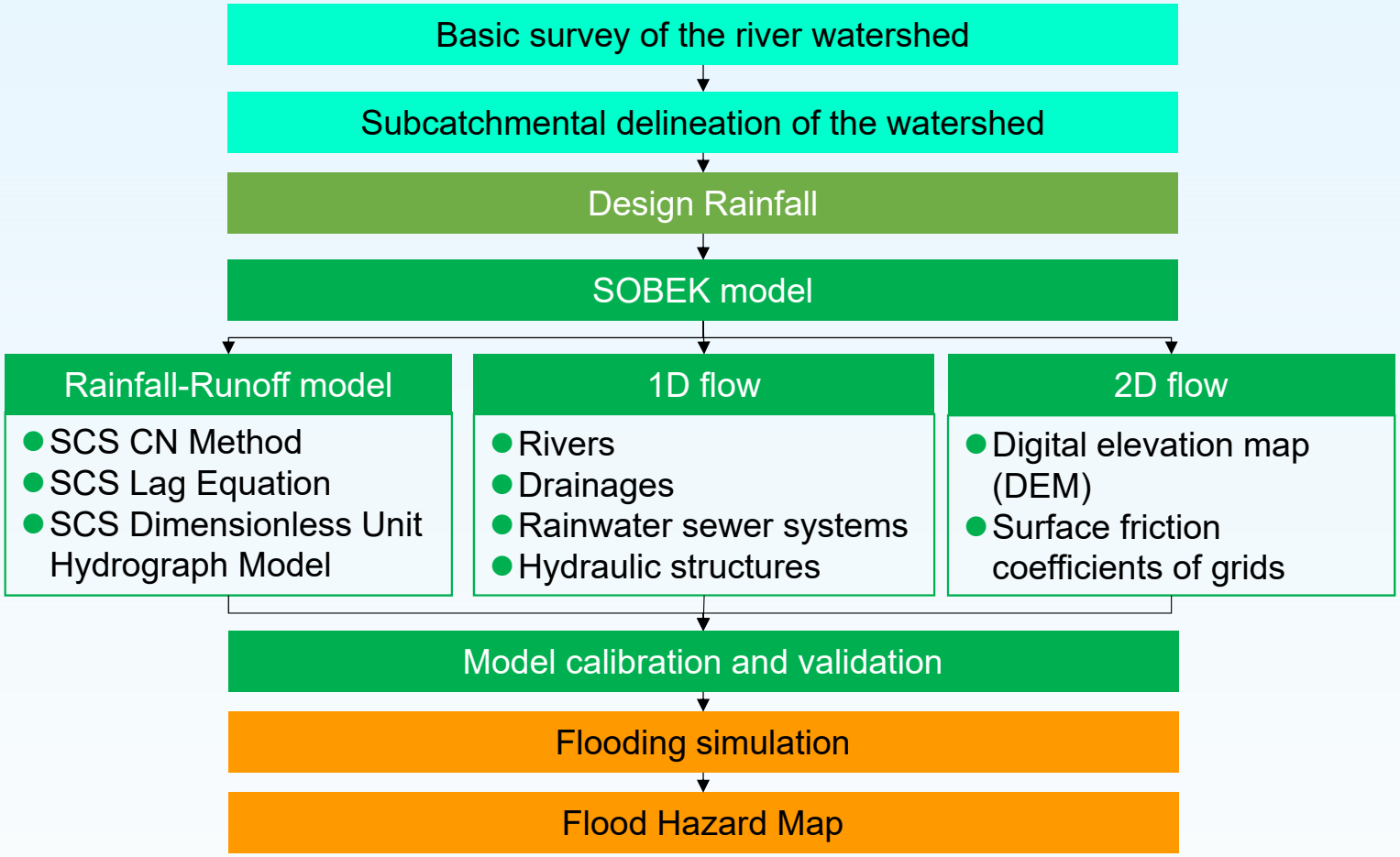



# 淹水潛勢圖資演進
## Evaluation of Flood Hazard Map

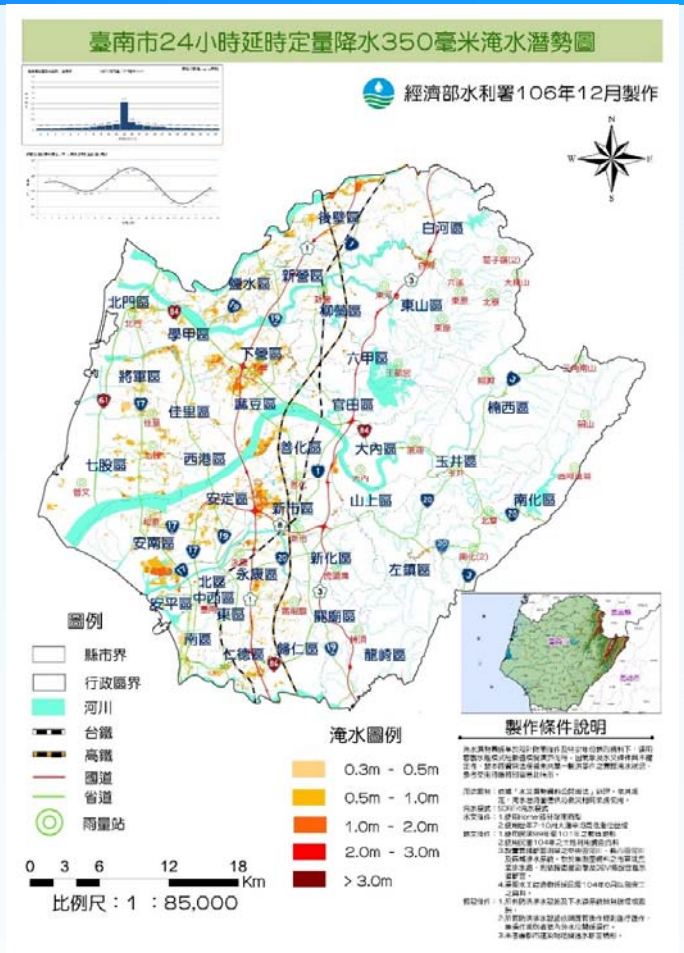
| 淹水潛勢圖 | 第一代 1st | 第二代 2nd | 第三代 3th |
|---|---|---|---|
| 發布時間 | 1999~2001 | 2007~2009 | 2014~2016 |
| DTM Resolution n(x,y,z) | 200m×200m×1m | 40m×40m×0.1m | 40m×40m×0.1m<br>10m×10m×0.1m |
| DTM | 採農林航測所於1981~1989測量相片基本圖之資料 | 採內政部於2008更新完成之數值高程 | 採內政部於最新年份完成之數值高程 |
| 模式選定 Numerical Model | 二維零慣性模式<br>2D non-inertia wave model | Sino-Topo<br>2D non-inertia wave model | SOBEK |
| 模擬情境 Scenarios | 定量降雨：<br>Quantification Rainfall<br>1-Day<br>150、300、450、600 mm | 定量降雨 Quantification Rainfall<br>1-Day<br>200、350、450、600 mm<br>2-Day<br>450、600、750、900 mm<br>3-Day<br>750、900、1050、1200 mm<br><br>重現期降雨<br>Return Period Rainfall<br>(24-hr)<br>1.1、2、5、10、20、25、50、100、200、500-year | 定量降雨Quantification Rainfall<br>6-hr：<br>100、150、200、250、300、350、400、450、500 mm<br>12-hr：<br>150、200、250、300、350、400、450、500、550 mm<br>24-hr：<br>200、250、300、350、400、450、500、650、800 mm<br>重現期降雨Return Period Rainfall<br>(6、12、24-hr)：<br>2、5、10、25、50、100、200、500年<br>重現期+越波(24小時)<br>Return Period Rainfall + Overtopping<br>2、5、10、25、50、100、200、500年 |
| 模式輸入 Model input | --- | 中央管河川與區域排水<br>River, Regional drainage | 河川、區域排水、雨水下水道、水庫、閘門、抽水站、滯洪池、重要橋樑等<br>River, Drainage, Sewer, Reservoir, Gate, Pumping Station, Detention Basin, Bridge |

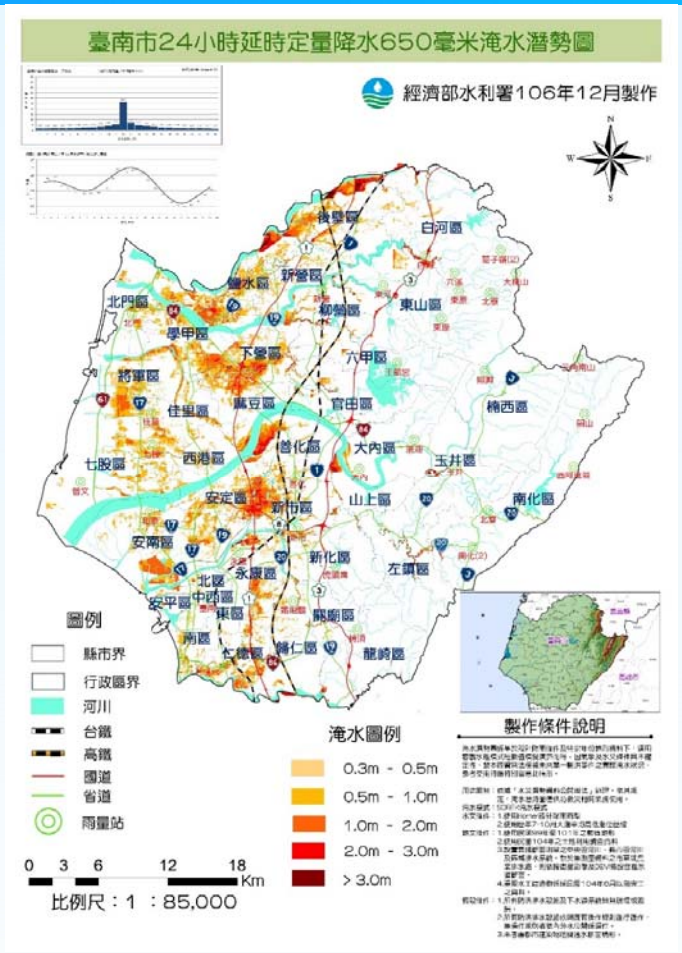
- 精度提升
- 增加水工結構物
- 模擬情境增加

# 淹水潛勢圖繪製流程
# Process of Flood Hazard Mapping



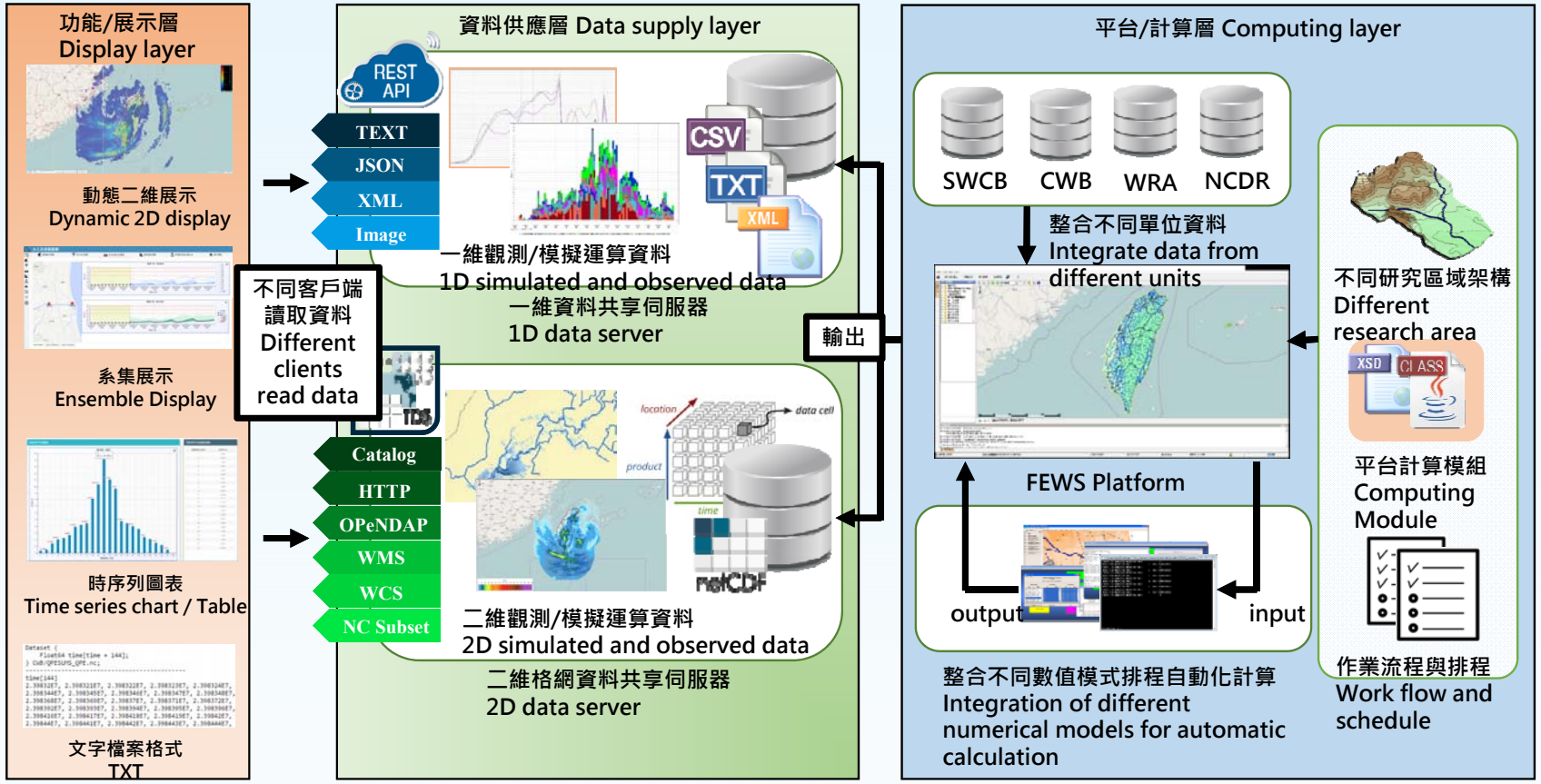
# 第三代淹水潛勢圖
## The 3th Generation Flood Hazard Map




資料來源:臺灣水災潛勢風險圖資應用服務平台

# FEWS系統架構概念
## Architecture diagram of FEWS system



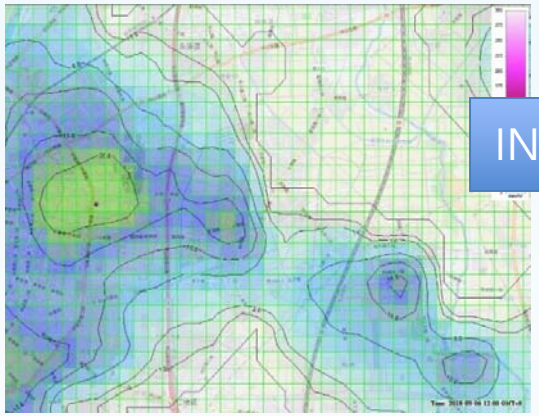

圖片來源:張哲豪

# 二維即時淹水預報系統
# Two-Dimensional Real-time Flooding Forecasting System

- 二維即時淹水預報系統透過FEWS-TAIWAN平臺，整合中央氣象局系集模式颱風定量降水預報與SOBEK模式，預報未來3小時的淹水情形。

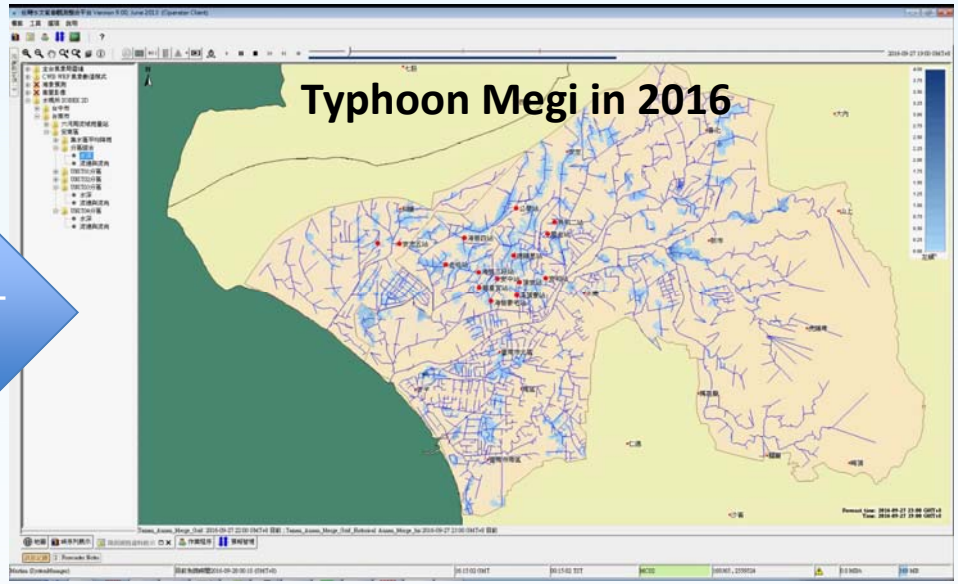
  Two-Dimensional Real-time Flooding Forecasting System uses the **Delft-FEWS** (Flood Early Warning System) platform to integrate the Ensemble Typhoon Quantitative Precipitation Forecast (**ETQPF**) of Central Weather Bureau and **SOBEK** models to forecast flooding in next 3 hours.

Ensemble Typhoon Quantitative Precipitation Forecast (ETQPF) from Central Weather Bureau



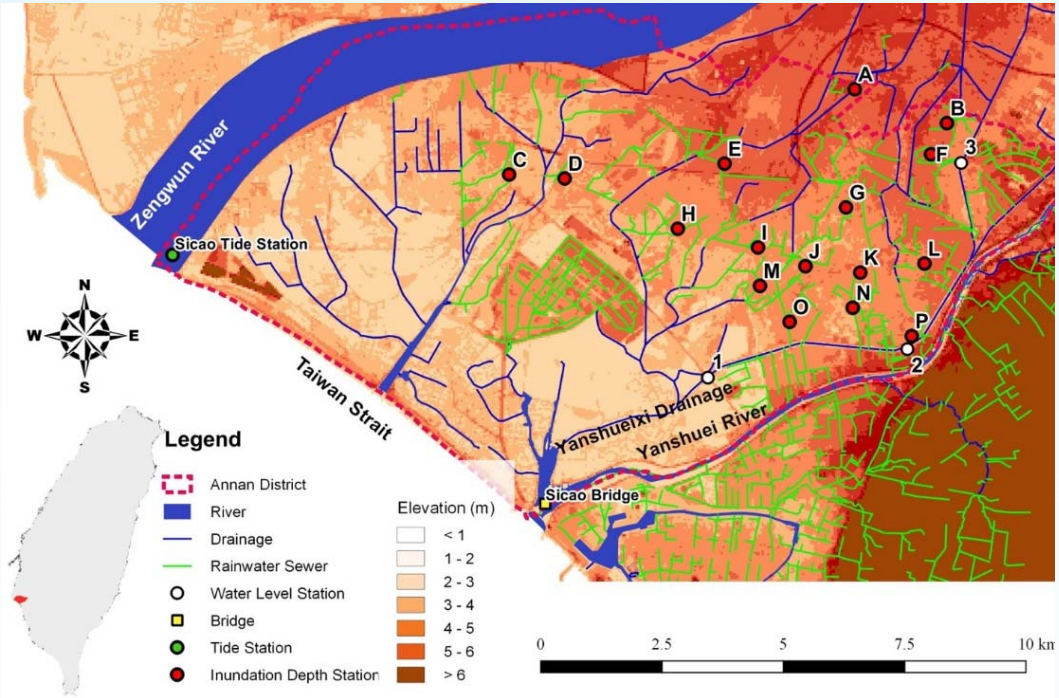
INPUT

SOBEK model



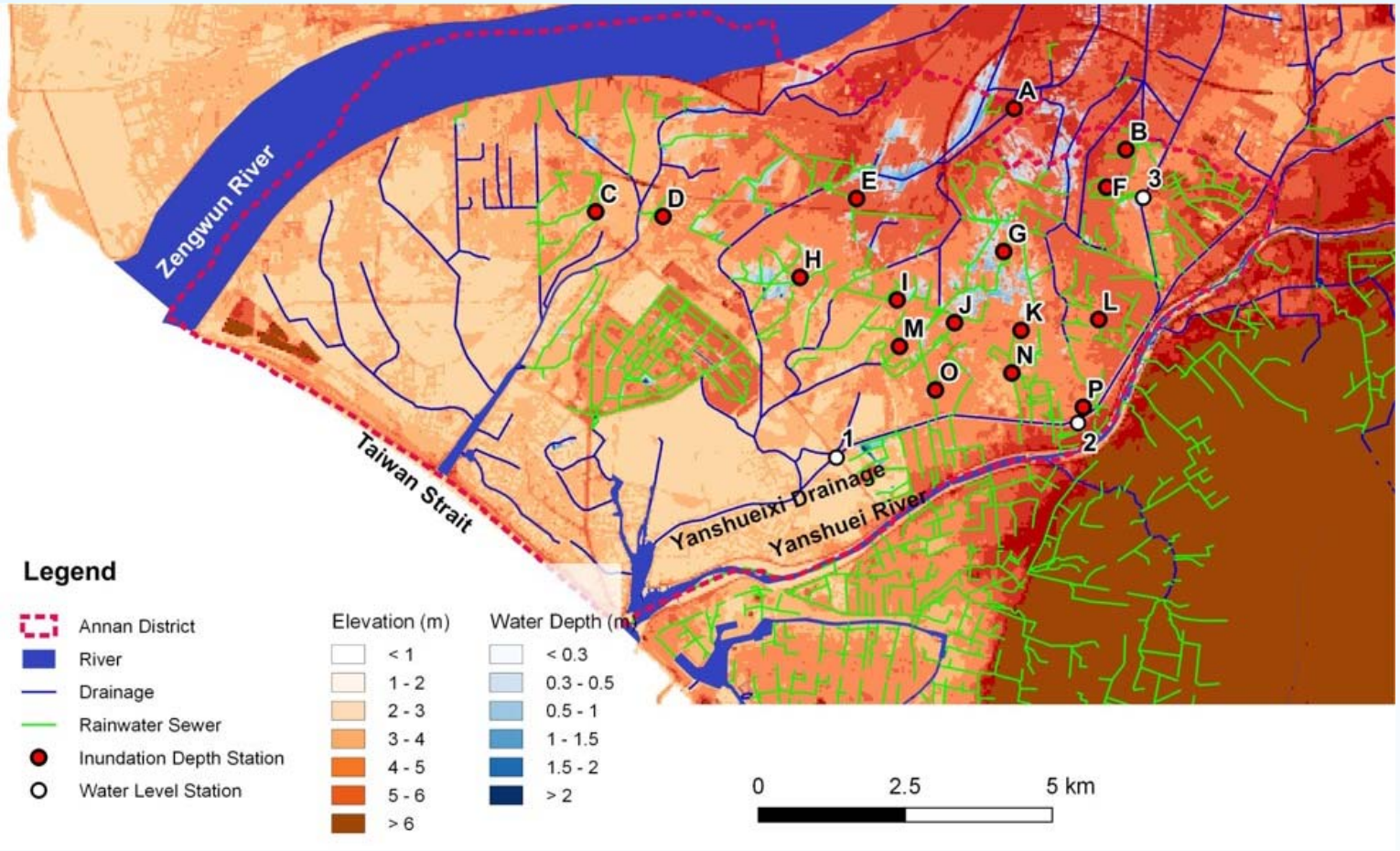
# 智慧水尺
## Smart water level gauges

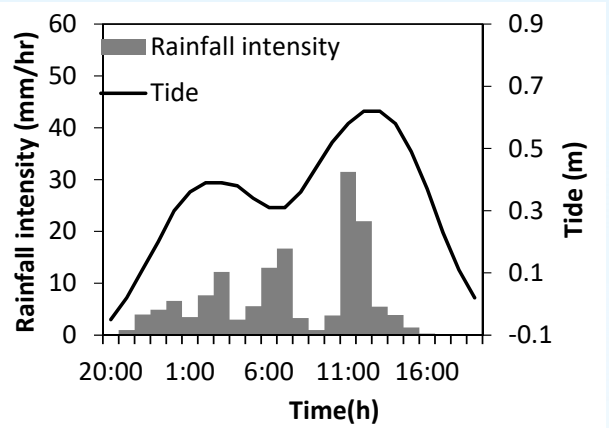
- Sixteen smart water level gauges were set up in the field to detect the inundation depths on the roads and to assess the accuracy of model.
- Real-time water levels are transmitted to the cloud system by a low-power wide-area network (LPWAN), such LoRa or NB-IoT.



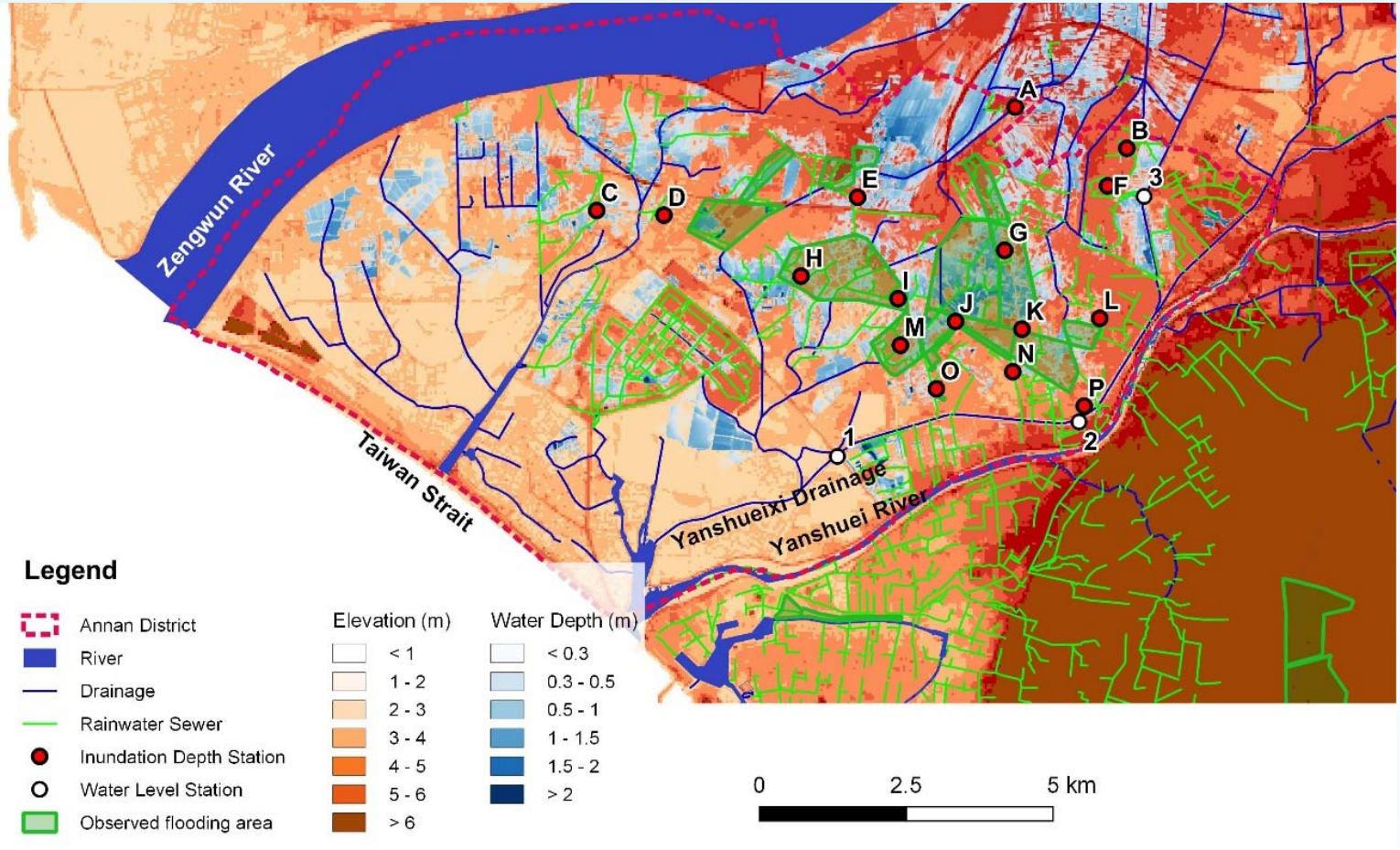

Chang, C-H, M-K Chung, S-Y Yang*, C-T Hsu and S-J Wu, 2018, A Case Study for the Application of an Operational Two-Dimensional Real-Time Flooding Forecasting System and Smart Water Level Gauges on Roads in Tainan City, Taiwan, Water, 10(5):574-589

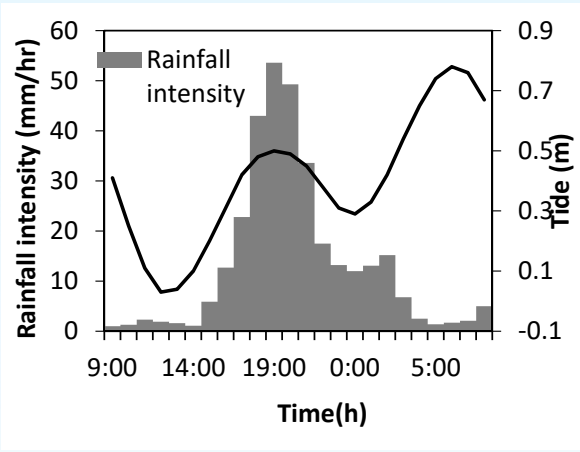
# 2016年0611豪雨模擬淹水範圍
## Simulated flooded area of Storm 0611 in 2016



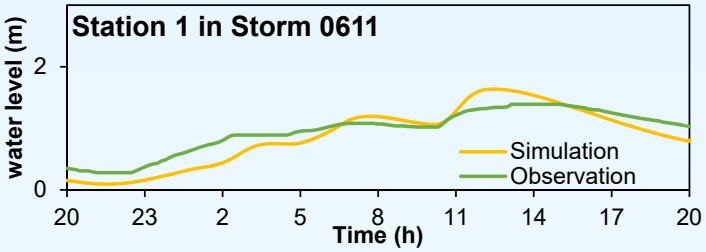



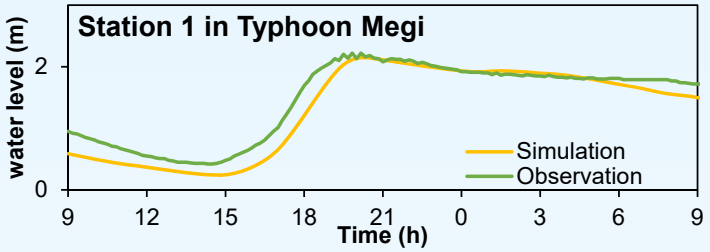
# 2016年梅姬颱風模擬淹水範圍
## Simulated flooded area of Typhoon Megi in 2016

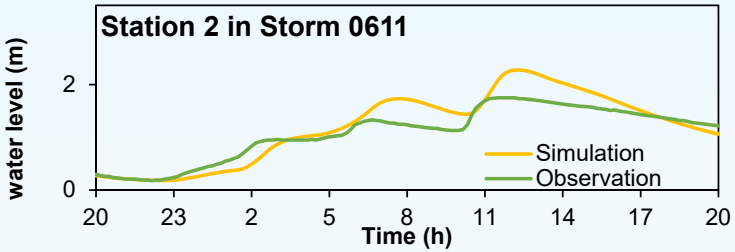


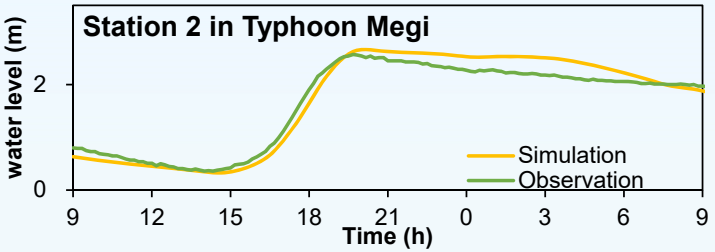



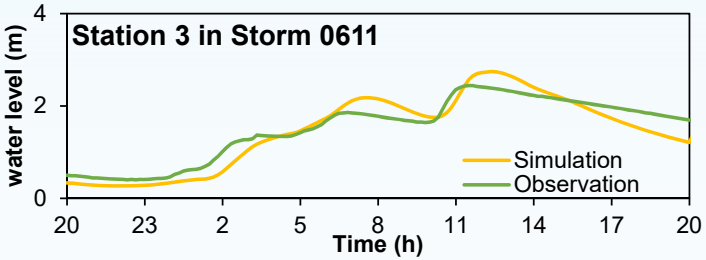
# 區域排水水位站
# Water level hydrographs in Drainages

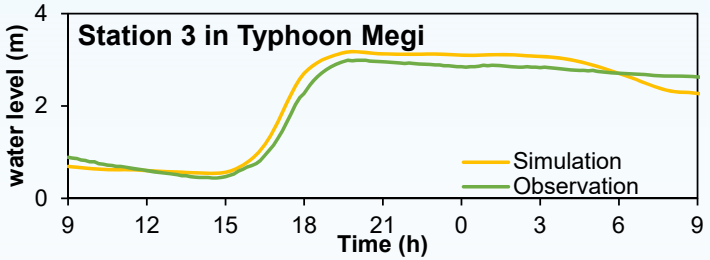


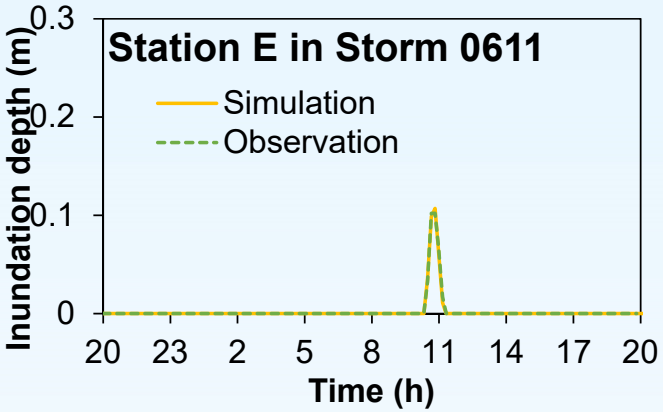



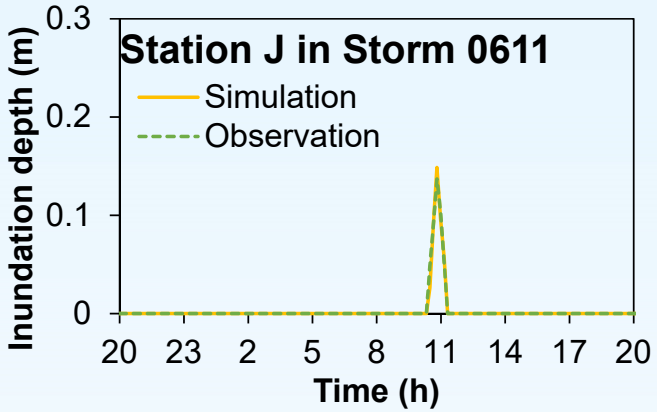



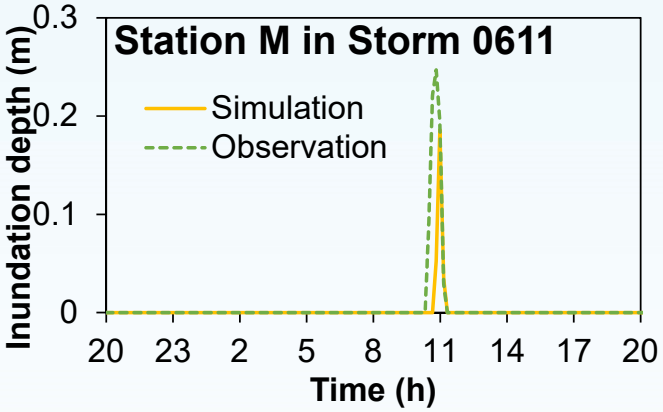



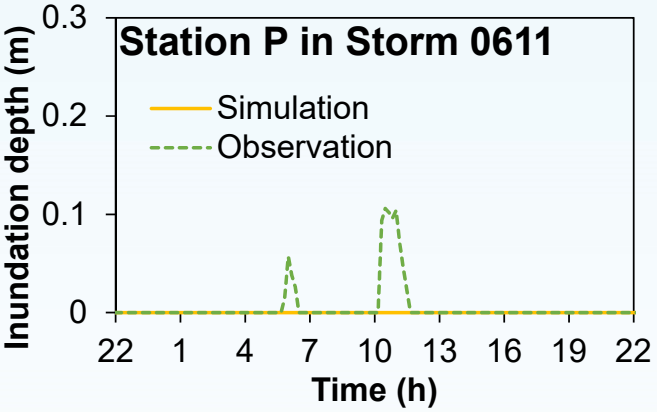



# 2016年0611豪雨道路淹水深度
## Inundation depth hydrographs of Storm 0611 in 2016

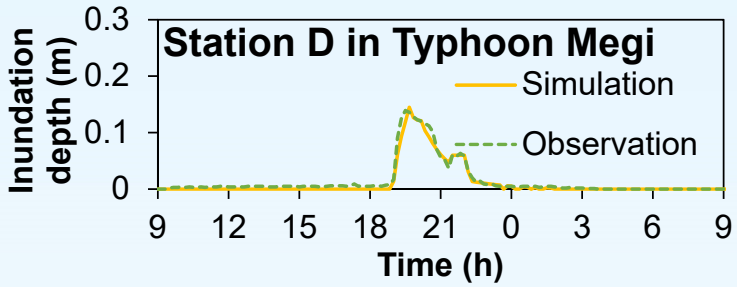


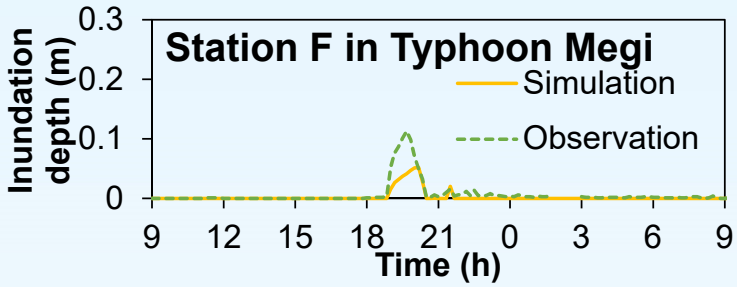



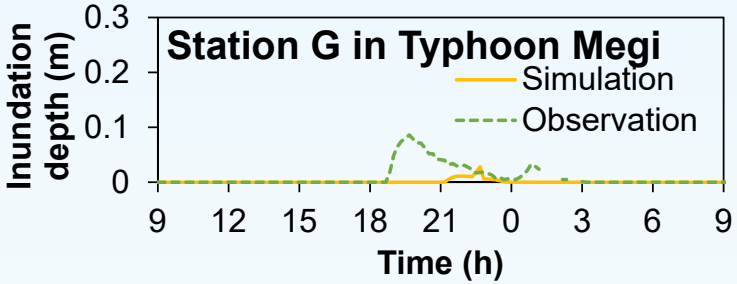



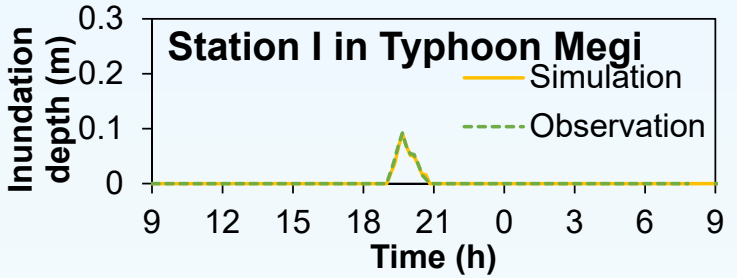



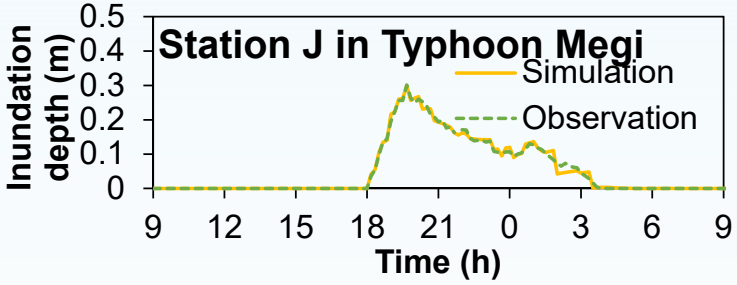
# 2016年梅姬颱風道路淹水深度
## Inundation depth hydrographs of Typhoon Megi in 2016

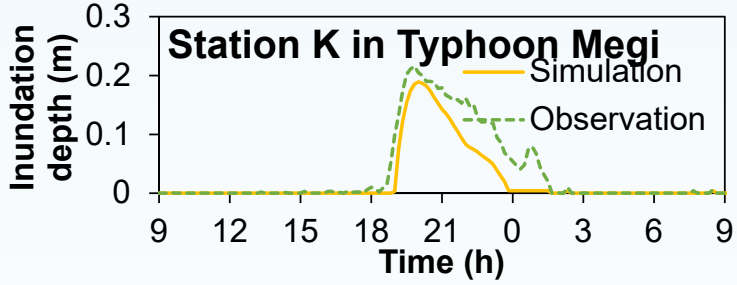


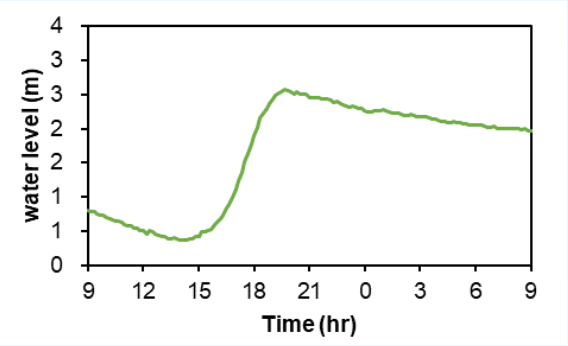



# 混淆矩陣
Confusion matrix

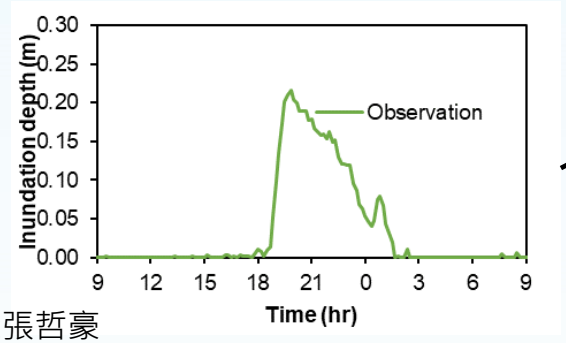
| Simulation | Observation | |
|---|---|---|
| | Positive | Negative |
| **Positive** | 8 (TP) | 0 (FP) |
| **Negative** | 2 (FN) | 8 (TN) |

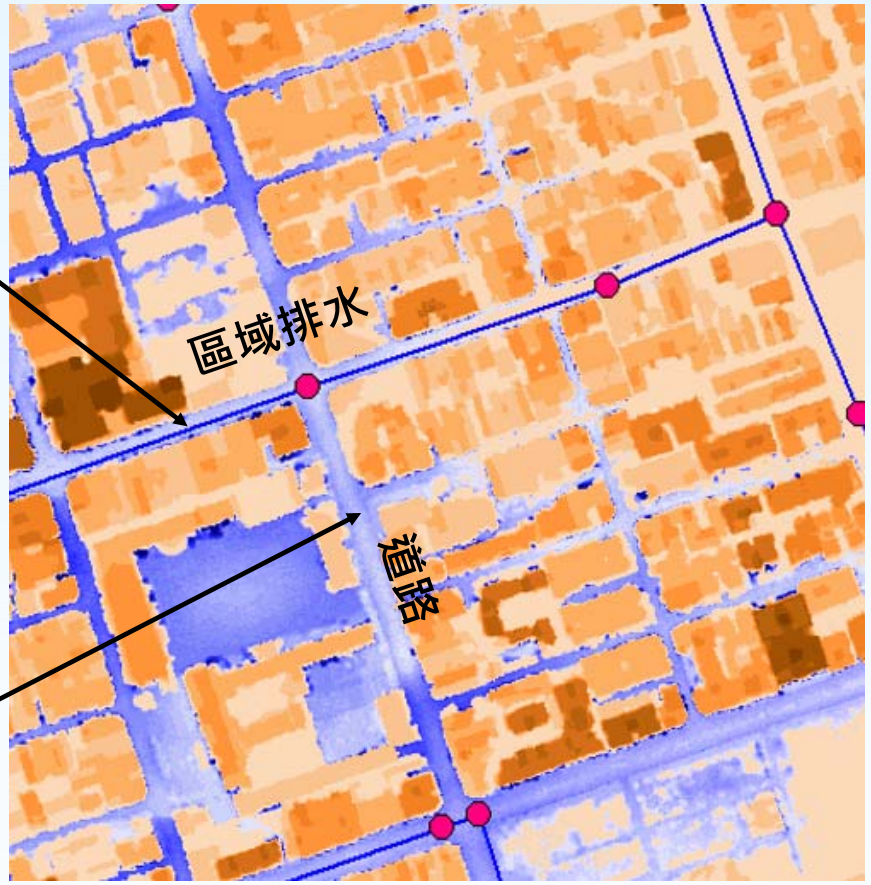
# 應用LSTM、GRU、HRNN預測區域排水水位與道路淹水深
## Application of LSTM, GRU, and HRNN to predict water levels in regional drainages and flooded depth on roads

區域排水現地觀測水位



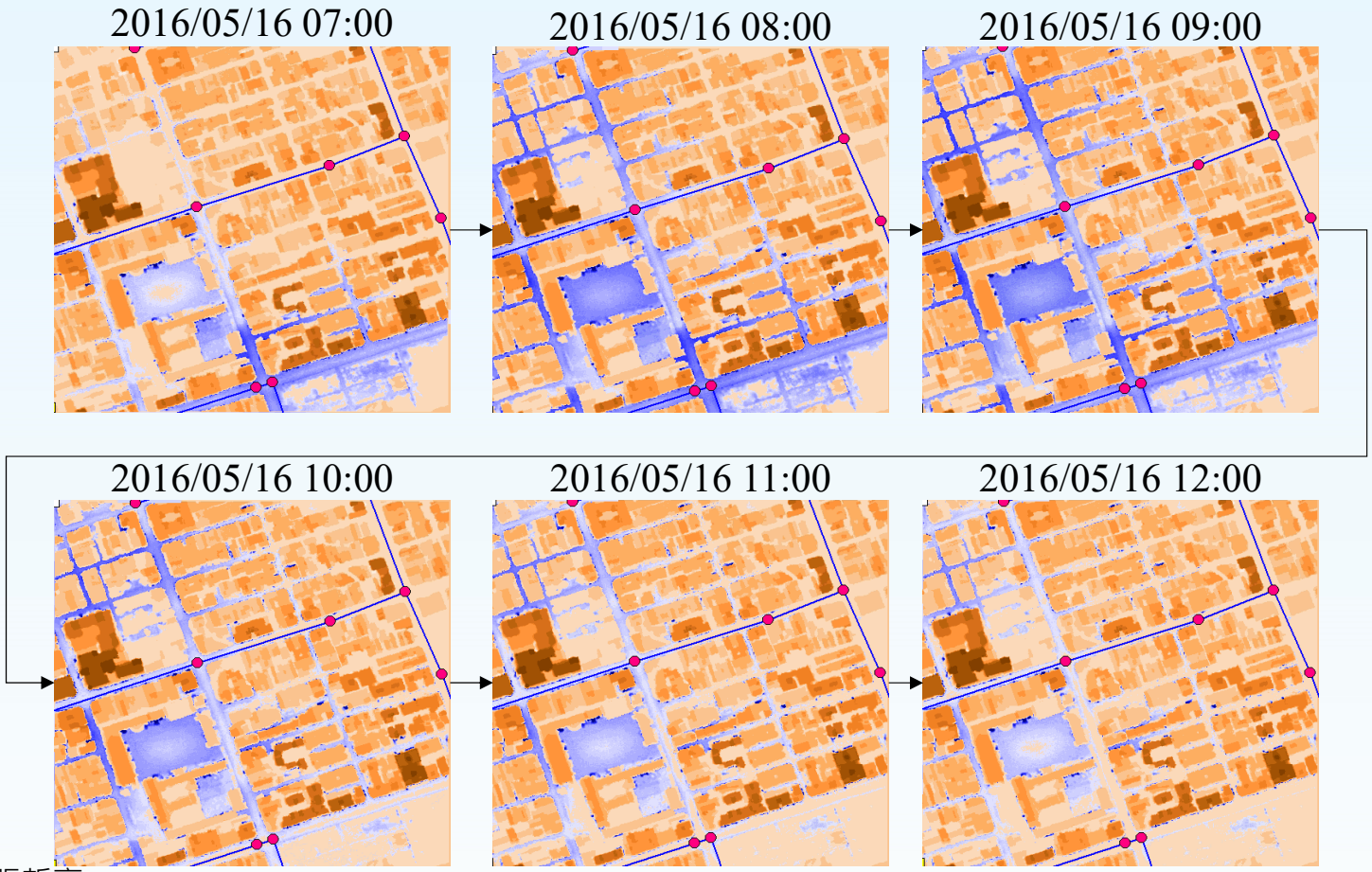

道路淹水現地觀測水位




圖片來源:張哲豪

# 應用卷積類神經預測淹水範圍
## Application of Convolutional Neural Network to predict flooded area




圖片來源:張哲豪


thank you
danke
謝謝
gracias
merci
obrigado
dziękuję
bedankt
спасибо
рахмат
Баярлалаа
ngiyabonga
شكراً جزيلاً
teşekkür ederim
dank je
tapadh leat
mochchakkeram
go raibh maith agat
sukriya
kop khun krap
arigatô
dakujem
grazie
terima kasih
감사합니다
ευχαριστώ
мерси
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kiitos
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nanmi
dhanyavad
mauruuru
hvala
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didi madloba
najis tuke
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rahmet
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diolch
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merce
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grazzi
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хвала
asante
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tenki
obrigada
murakoze
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xièxie
enkosi
bayarlalaa
gràcie
köszönöm
sobodi
dēkuji
mèsi
তোমাকে ধন্যবাদ