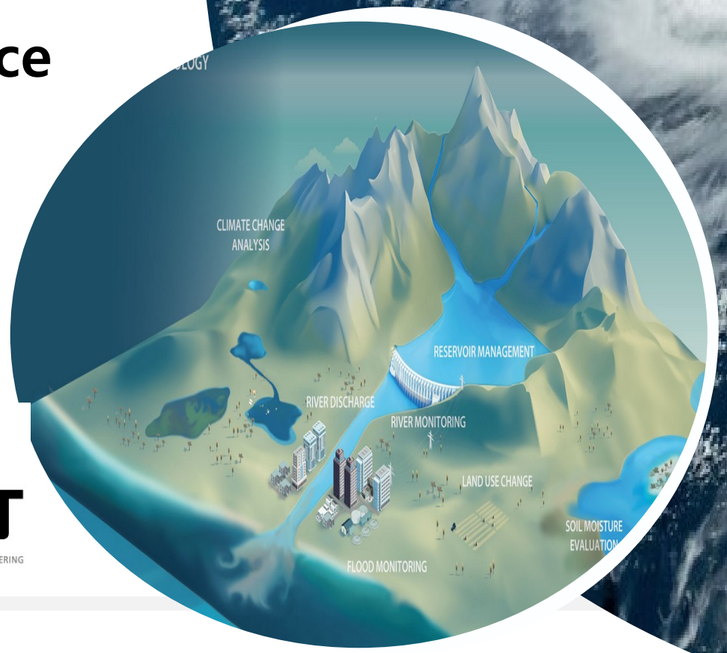
Introduction to the development and Operation of a flood forecasting System using AI techniques

The Republic of Korea

Yohan CHO
Han River Flood Control Office



58th Typhoon Committee session

10-13 March 2026, Jeju

ESCAP/WMO Typhoon Committee

Ministry of Climate, Energy and Environment
Han River Flood Control Office

KICT
KOREA INSTITUTE of CIVIL ENGINEERING and BUILDING TECHNOLOGY

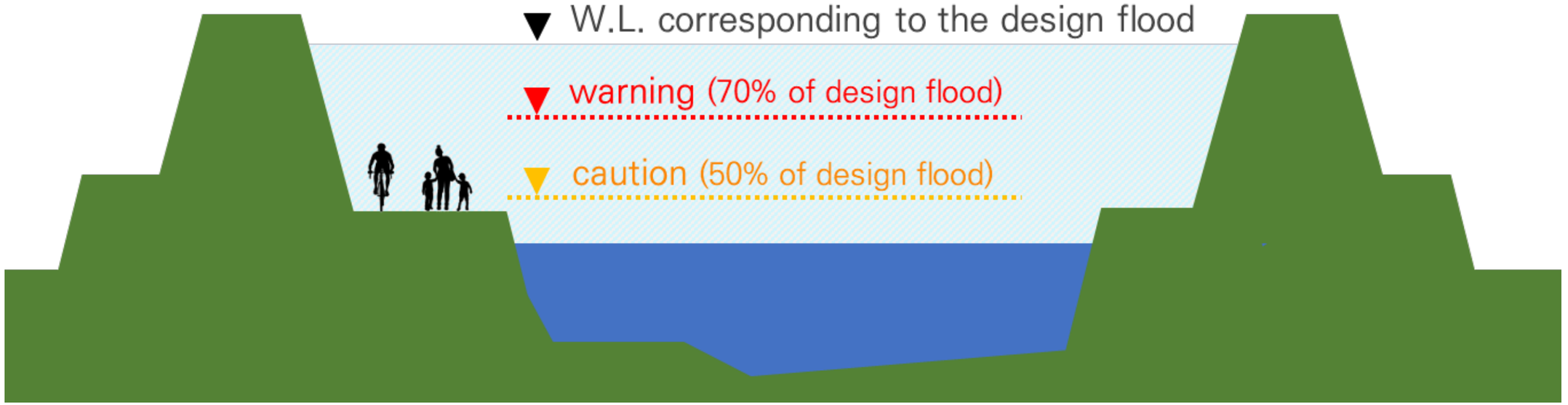
Contents

Overview

Flood Warning in Korea

When is an Flood Warning issued?

Flood warning issued when the W.L. at flood forecasting station is expected to exceed reference W.L.



Which agency issue Flood Warning?

4 Flood Control Offices and 1 branch office

❖ Total area : 100,793 ㎢

Han River FCO (1974)

Basin Area : 41,331 ㎢

Sumjin River Flood Control Branch Office(2022)

Basin Area : 4,913 ㎢

Yeongsan River FCO (1991)

Basin Area : 16,207 ㎢

Geum River FCO (1990)

Basin Area: 13,342 ㎢

Nakdong River FCO (1987)

Basin Area : 30,020 ㎢

Main missions

- **Water resources survey**
  Hydrologic survey, river basin investigation, flood and drought damage survey
- **Forecasting for flood and low flow**
  High and low flow control and management, Approval for discharge of dam and weir
- **Flow management in river**
  Linked operation dam and weir, permission of stream water usage
- **Informatization for water resources**
  Collection, management and release of water resources information
- **International cooperation**
  Typhoon Committee, WMO

Flood Forecasting Procedure

Observation& Survey

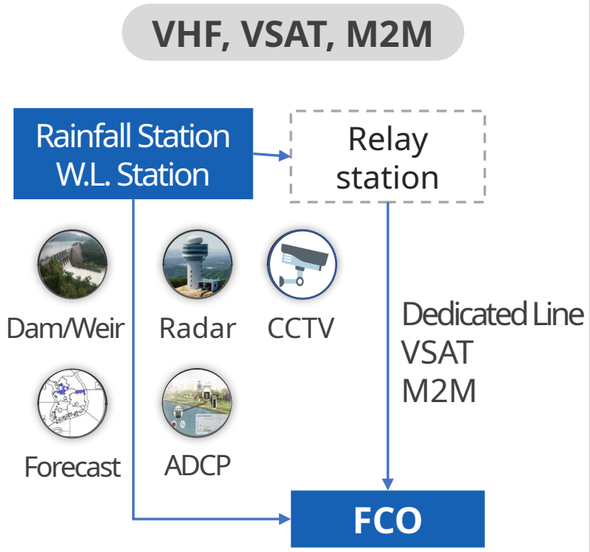
Rainfall radars
* S-band, Alt. 1.0km
  X-band, Alt. 0.5km

427 Rainfall Stn.
* 486 planned by 2029

933 Water level Stn.
* 238 constructed in 2024

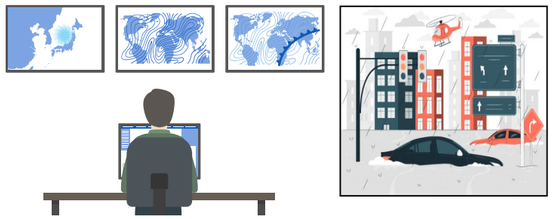
Runoff survey
* 860 by man, 73 by automated

Data collecting



- ✓ VHF : High frequency telecommunication
- ✓ VSAT : Satellite communication
- ✓ M2M : Network used by mobile phones

Analyzing & Forecasting



- **Data analysis**
  * Weather, dam, rainfall, W.L. ...
- **Scenario review**
  * Dam discharge, W.L., runoff, etc.
- **Forecasting and decision**
  - ✓ Analysis of effect of dam discharge
  - ✓ Water level and runoff forecast
  - ✓ Data check, scenario rebuild

Issuance & Dissemination

223 flood forecasting site
933 information sites

Phone, Fax
Alert message(CBS)
Disaster broadcast
SMS, MMS
Flood info. App
Navigation
homepage

- ✓ Flood control room of MCEE
- ✓ Disaster and Safety Headquarters
- ✓ Local gov. disaster headquarters
- ✓ Media organization(KBS etc.)
- ✓ Related agencies, community, police

New approach: AI tech.

AI Flood Forecasting System

Introduction of AI for Flood Forecasting

Background

Lack of forecasting system for small rivers

- Increased heavy rain frequency and rainfall due to climate change

➡ Damages in local(small) rivers more than damages in national(large) rivers

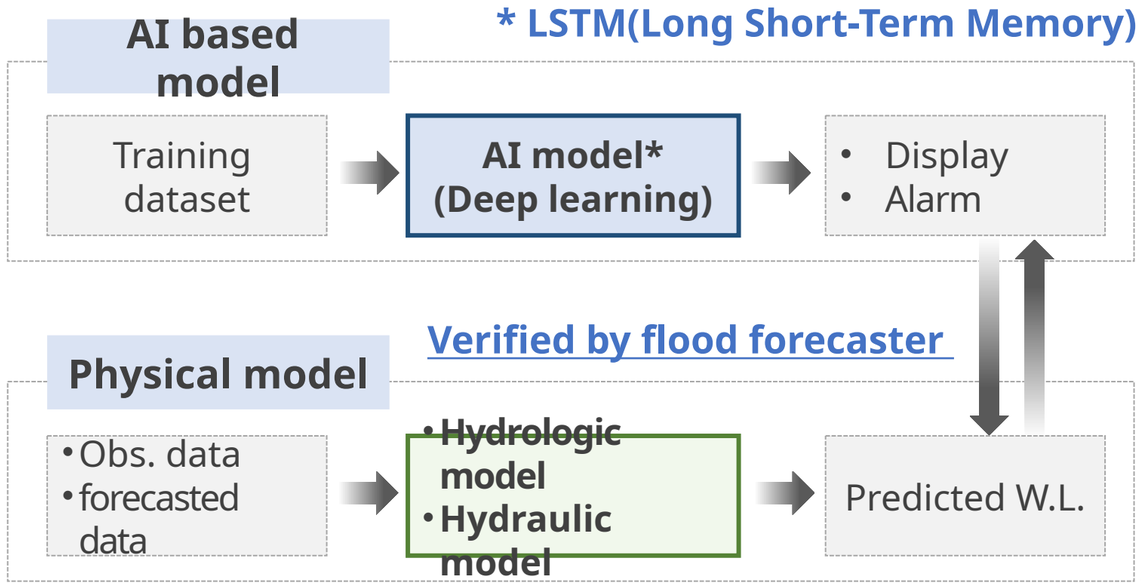
Need to improve forecasting method

- Flood forecasting and issuing by manpower

➡ Difficult to increase the number of flood forecasting stations

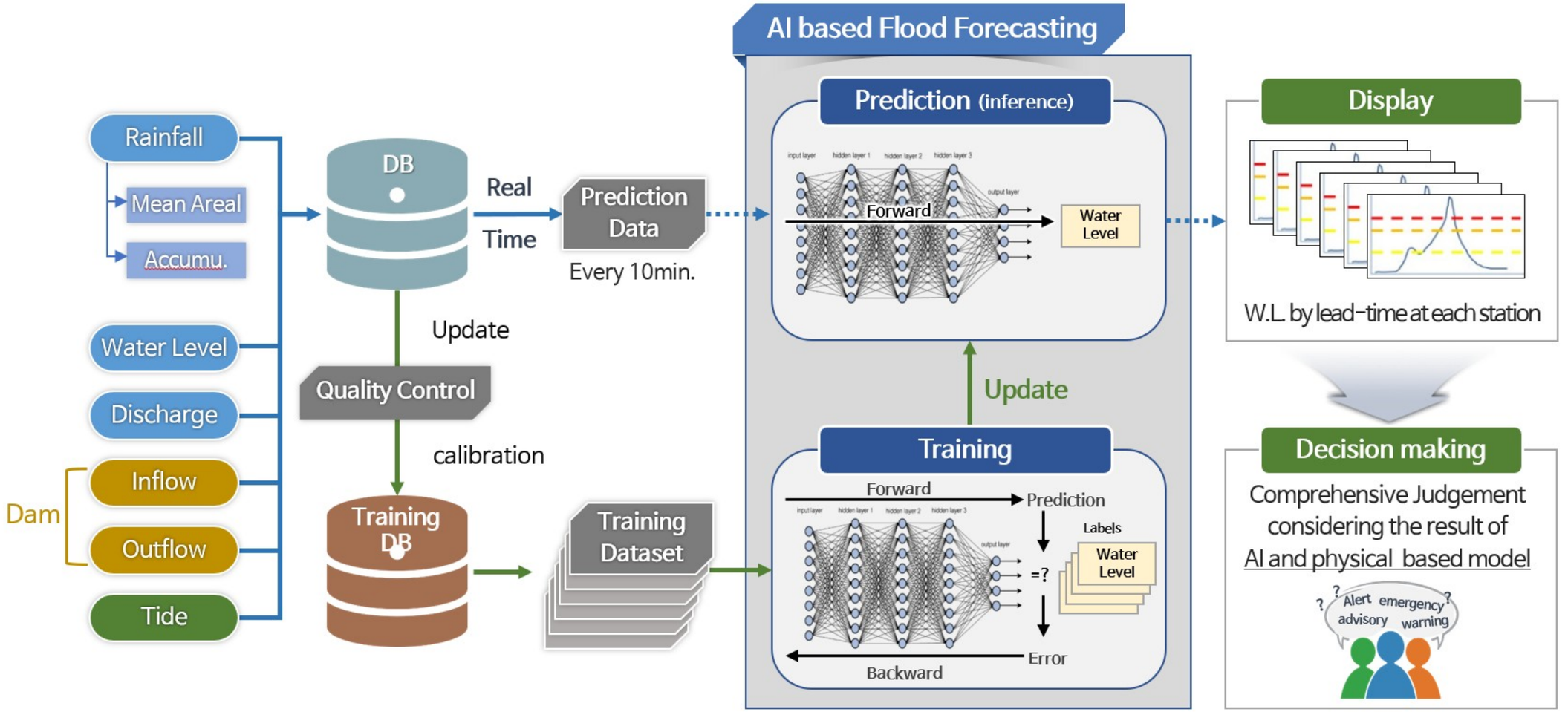
Improving the forecasting system

- Introducing AI to automatically and continu-ously calculate water level at many stations
- Add a forecasting model based on AI tech.



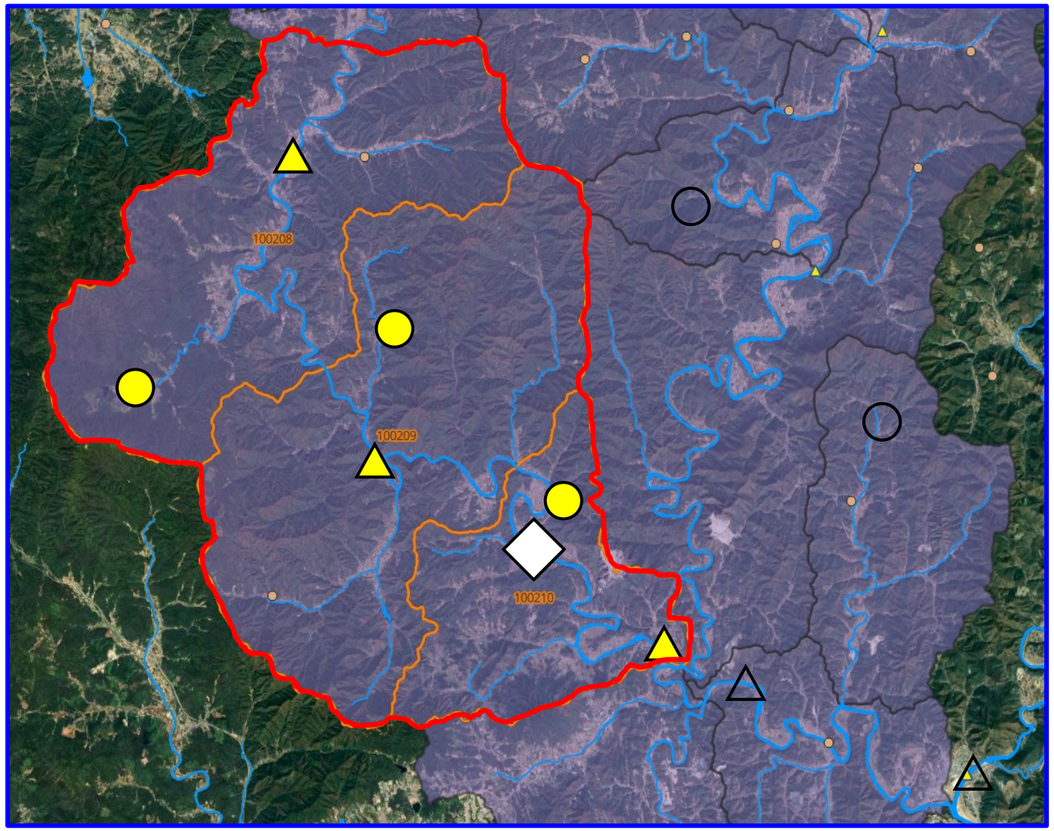
AI Model Building Process

Auto-prediction by AI / Alarm at flood risky station



Composition of Training Data

Target Water Level Station and Reference Stations(data)



- [**Water level station**] located upstream of target station as the reference data
  (If backwater is affected, we can select in downstream data)

- [**Rainfall station**] within watershed where target station is located

Target Water Level Station

Watershed

Water level stations as reference data

Rainfall stations as reference data

Dataset Structure

Example of DB table

Varies by station

Fixed at 36(10min~360min)

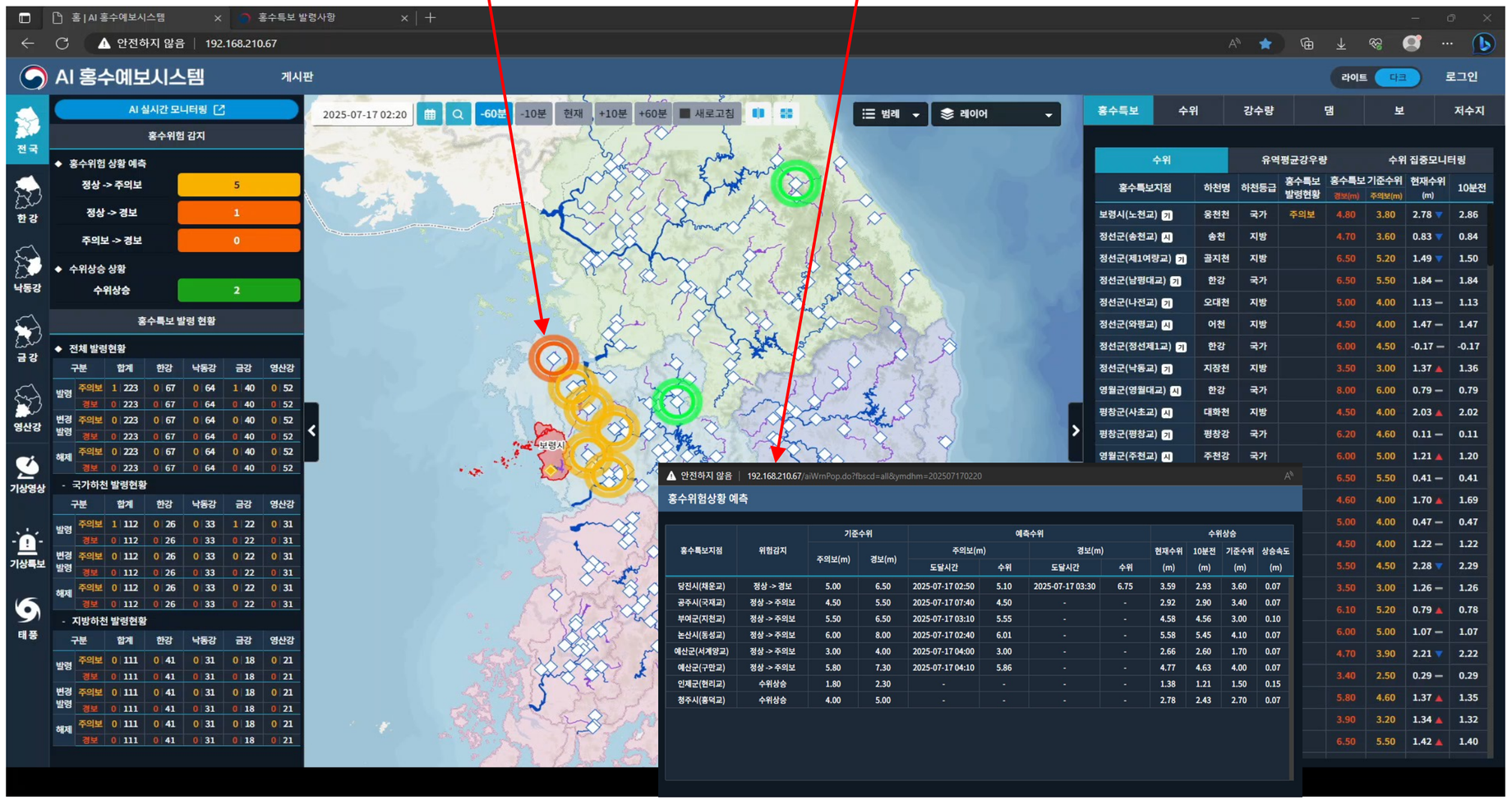
Training Data													Prediction(inference) Data						
Obs. Water Level				Obs. rainfall			Accumulated rainfall			Mean areal rainfall			Predicted Water Level(# of 36)						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	17	18	...	47	48	49
Target W.L. Station	WL1	WL2	WL3	RF1	RF2	RF3	RF1 _accum	RF2 _accum	RF3 _accum	Water Shed1	Water Shed2	Water Shed2	Lead Time 10min.	Lead Time 20min.	Lead Time 30min.	...	Lead Time 340min.	Lead Time 350min.	Lead Time 360min.

Sequence length

AI Flood Forecasting System(1/4)

Alarm at flood risky stations

Pop-up with detail information about the alarmed stations

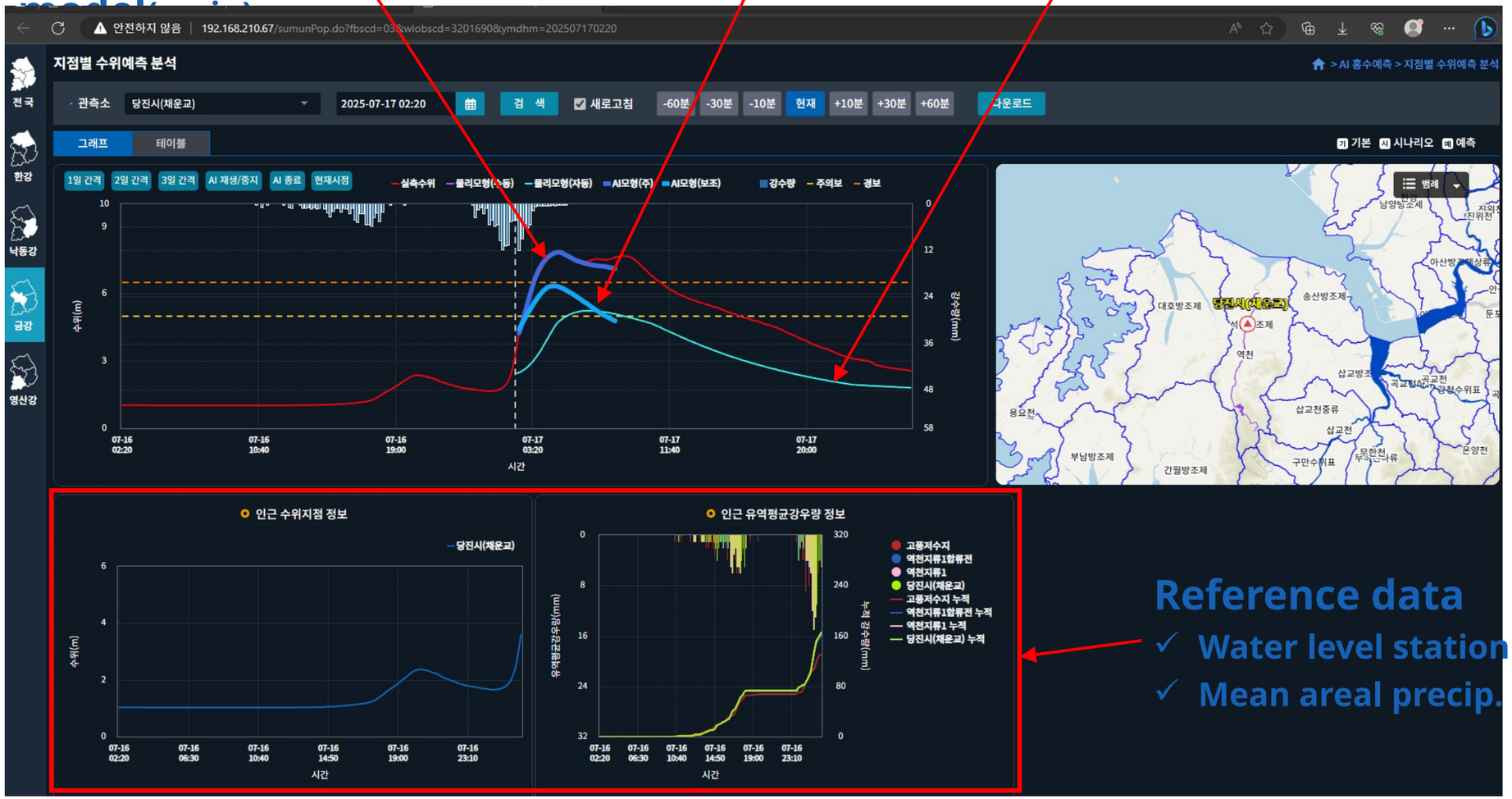


AI Flood Forecasting System(2/4)

Pred. by AI

Pred. by AI model(sub)

Pred. physics based model



Reference data

- ✓ Water level station
- ✓ Mean areal precip.

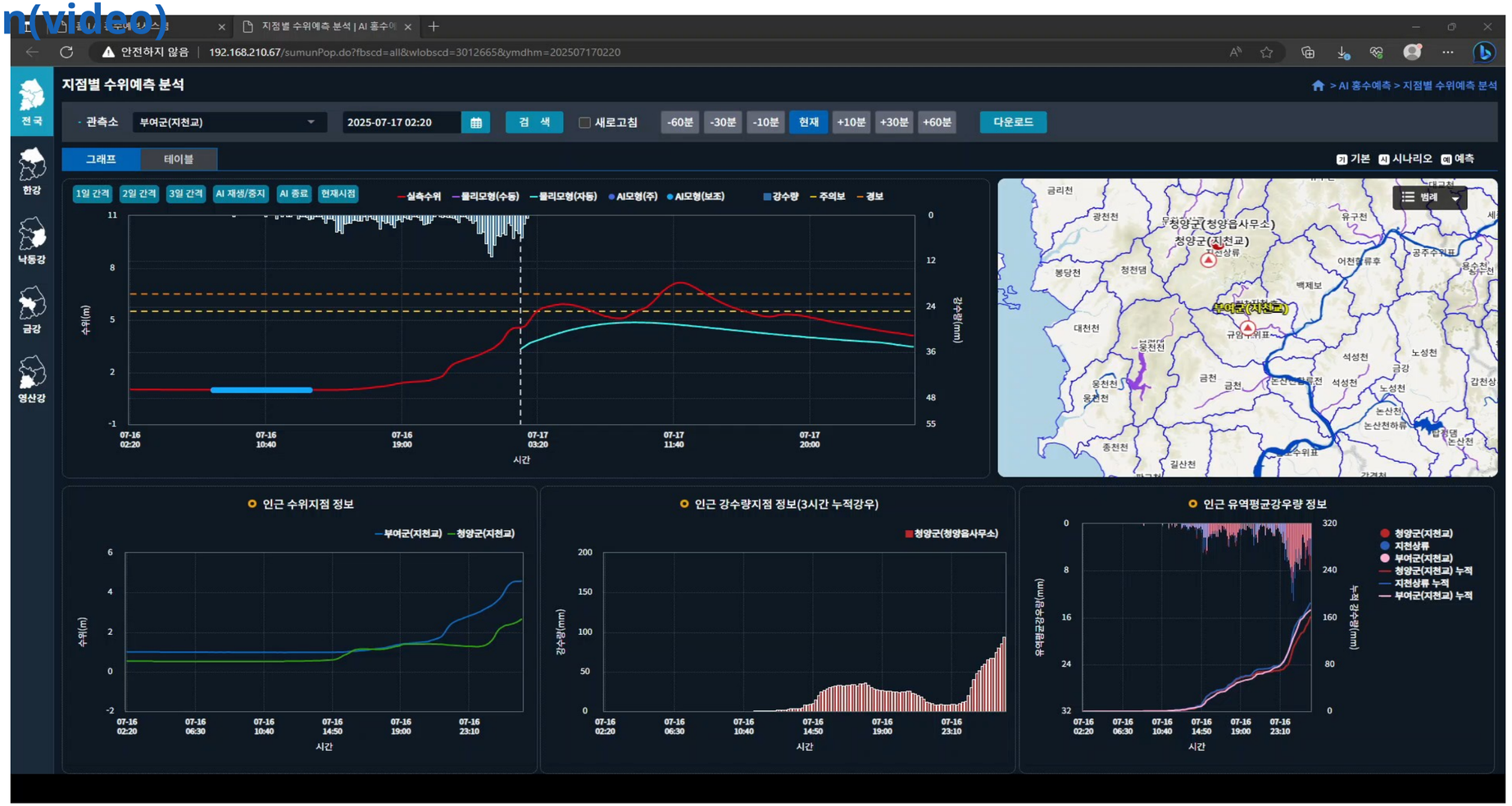
AI Flood Forecasting System(3/4)

Reference data

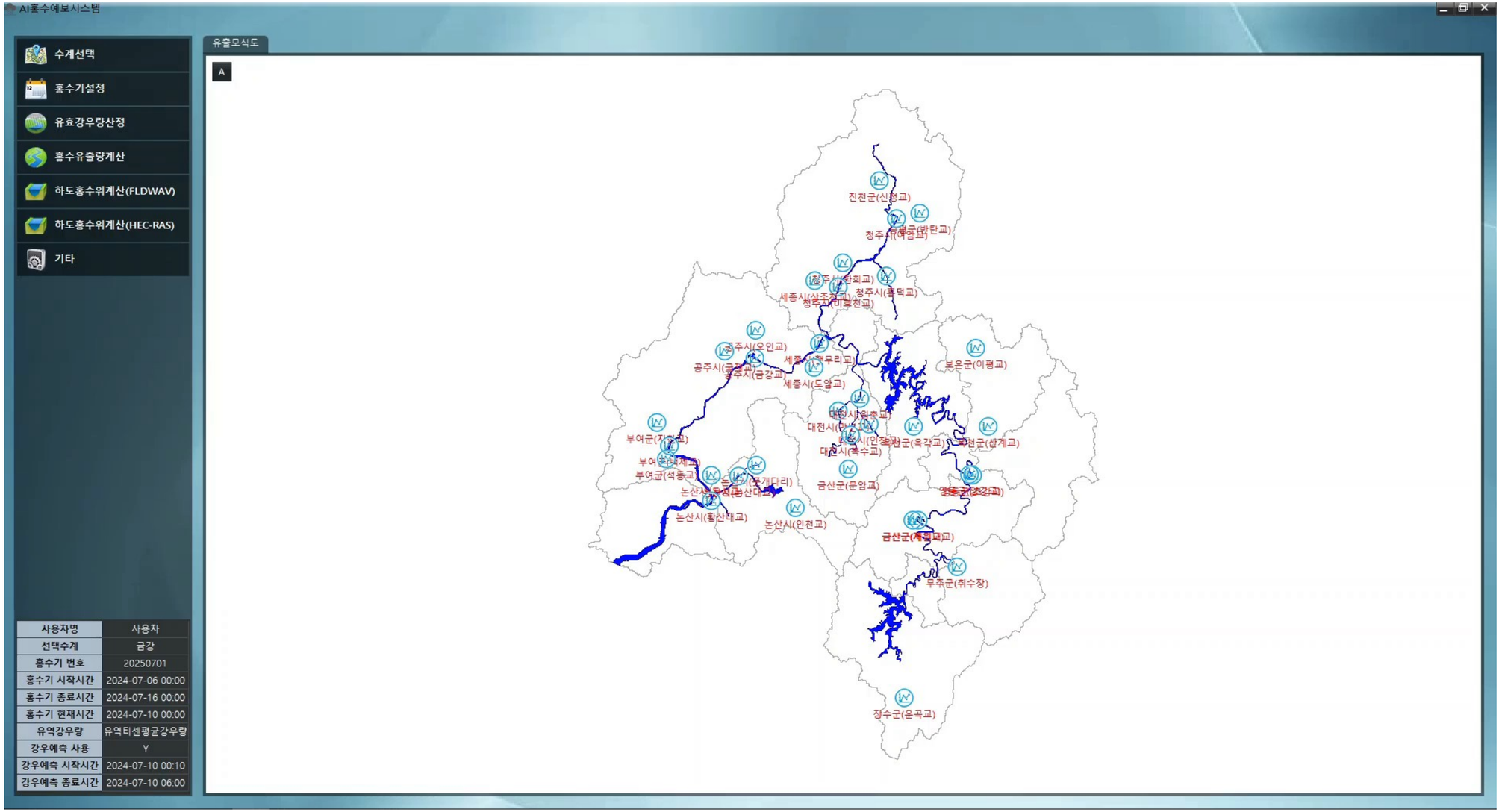
- ✓ Water level station
- ✓ Accumm. rainfall
- ✓ Mean areal rainfall

AI Flood Forecasting System(4/4)

Judging the validity of prediction using animation(video)



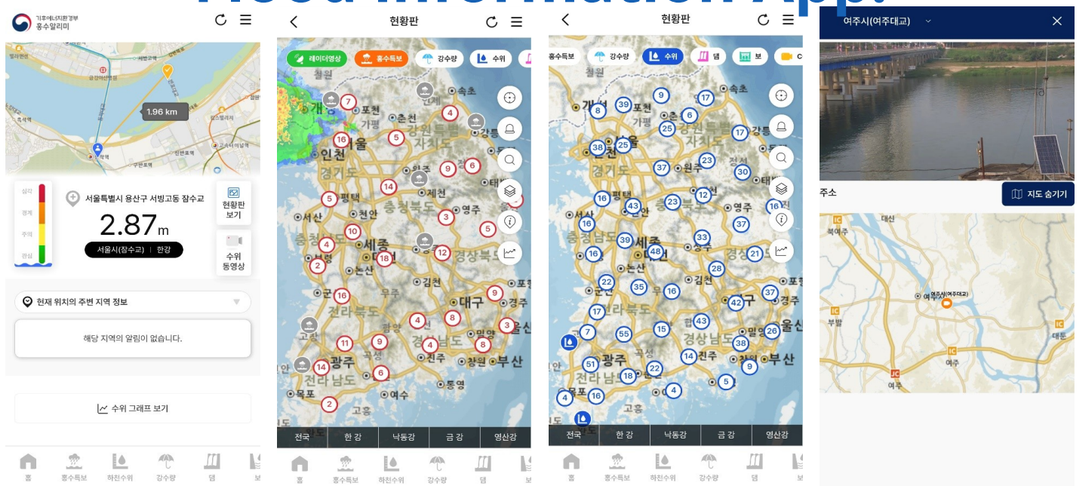
Verification using Physics based model



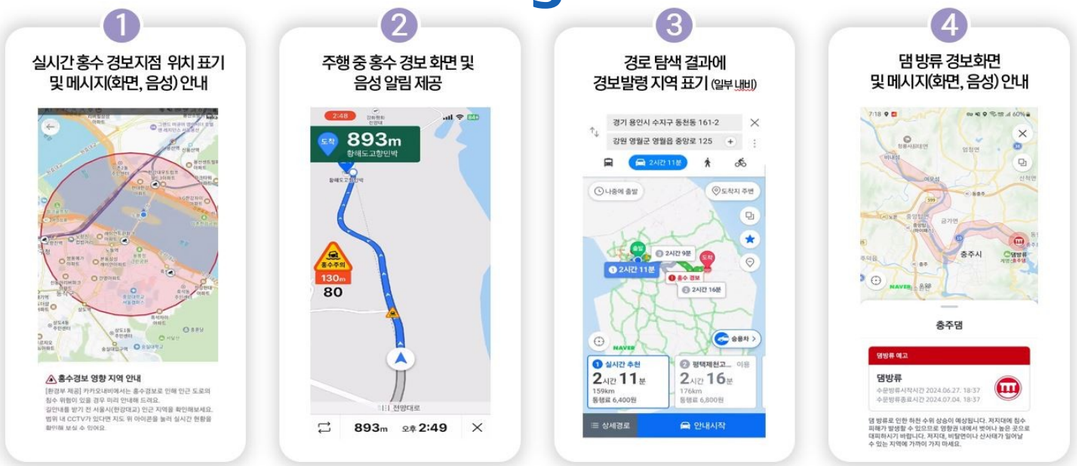
Delivery of Flood Warnings

Flood information

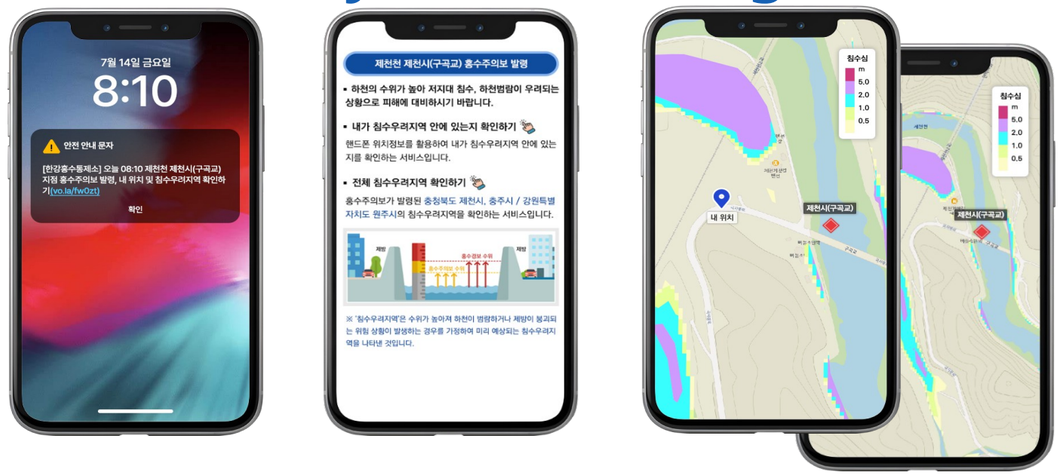
Flood information App.



Navigation



Safety Alert Message



Achievements and Management

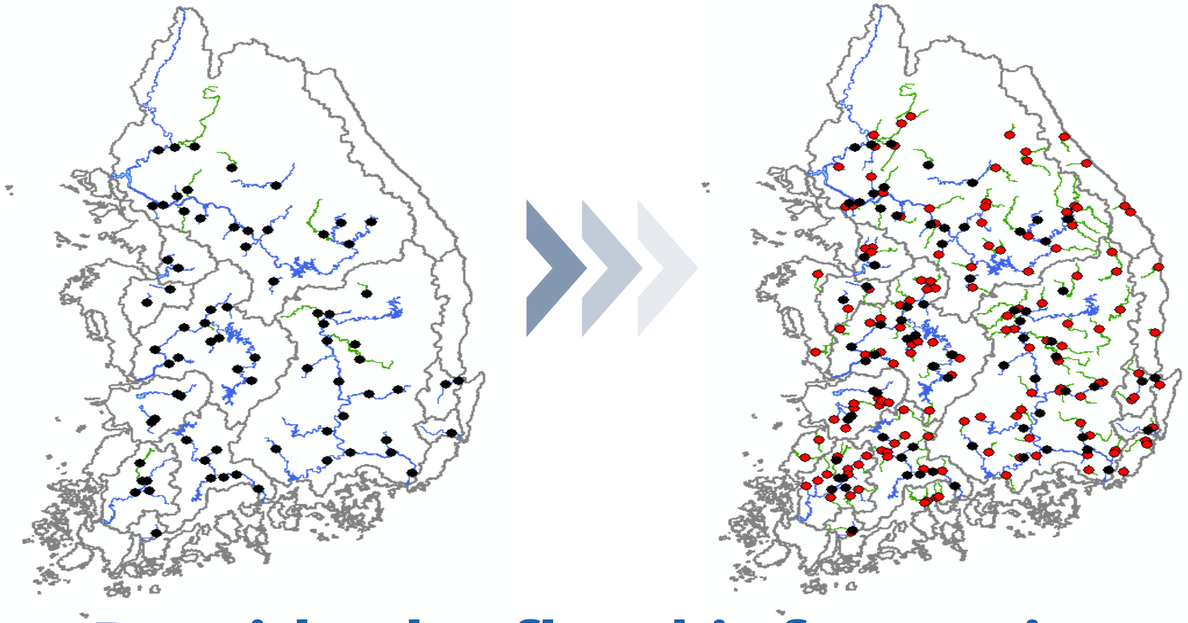
Increase in Flood Forecasting Stations and Warnings

[~2023] 75 stations

[2024~] 223 stations

National river stations 63 → 112

Local stream stations 12 → 111



Provide the flood information more than in the last 10 years

year	’14	’15	’16	’17	’18	’19	’20	’21	’22	’23	’24	’25
# of issues	9	-	12	10	26	25	122	5	37	96	170	180

What we learned form AI Flood Forecasting

- Flood Forecasting performance: suitable for issuing warning

- It is highly successful in terms of speed, dense surveillance network (including tributaries and streams), and actual damage prevention.

- Learning with more high-quality data

- Outlier removal to improve data quality
- Composition of learning materials with various scenarios such as floods and droughts
- Management of learning data and model version using MLOps (Machine Learning Operations)

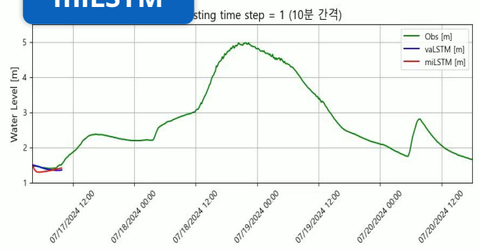
- Selection of deep learning technique

- LSTM has several variants depending on the data complexity, variable type, and prediction horizon.
- The choice of LSTM technique significantly affects not only prediction accuracy but also model efficiency (computational speed) and interpretability.

Improving Deep Learning Techniques

Improving current AI tech.

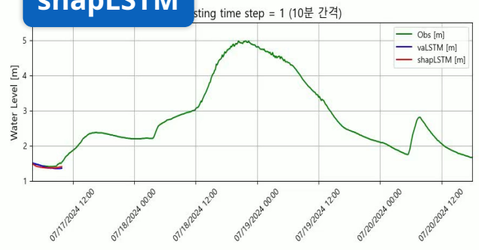
miLSTM



vmdLSTM

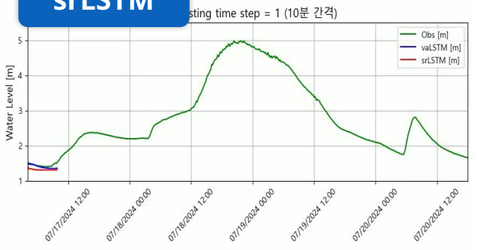
rsiLSTM

shapLSTM

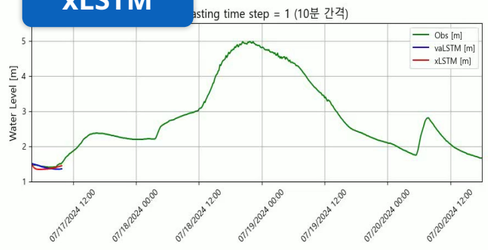


mhaLSTM

srLSTM

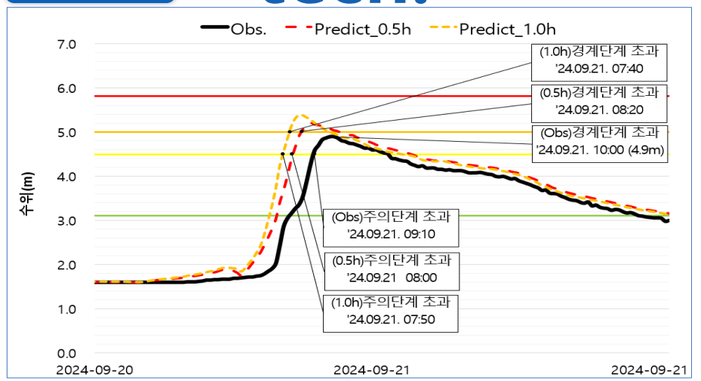


xLSTM

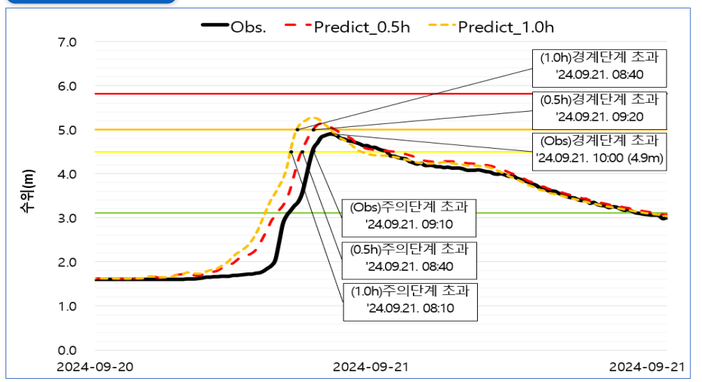


Reviewing new AI tech.

LSTM



LSTM+GRU



International cooperation

AOP led by ROK under Working Group

- Currently, there are TWO AOPs led by ROK under WGH, which are funded by HRFCO and conducted by KICT:
- 4 target member countries: **Lao P.D.R**, Malaysia, Philippines, and Thailand

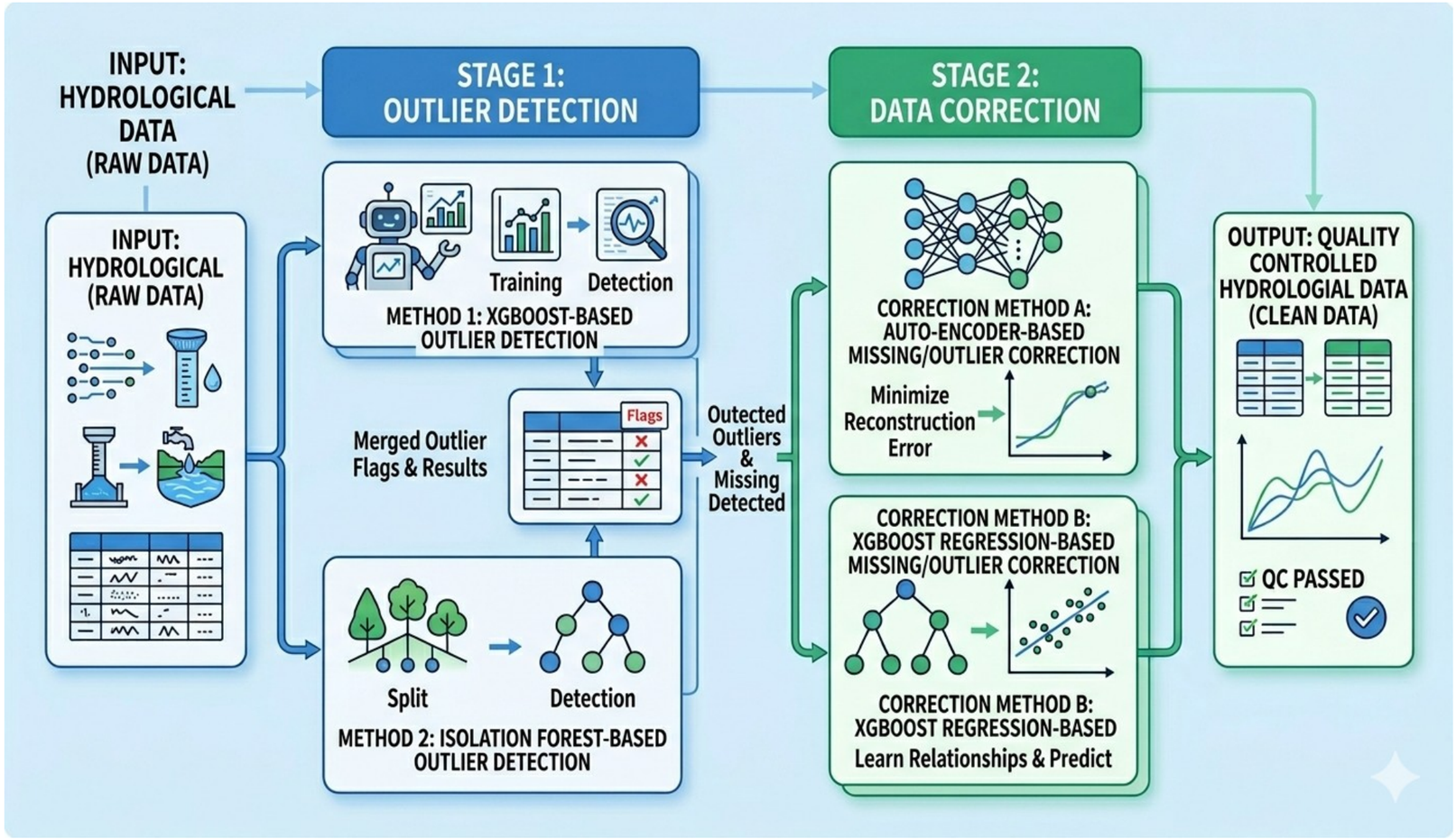
Hydrology

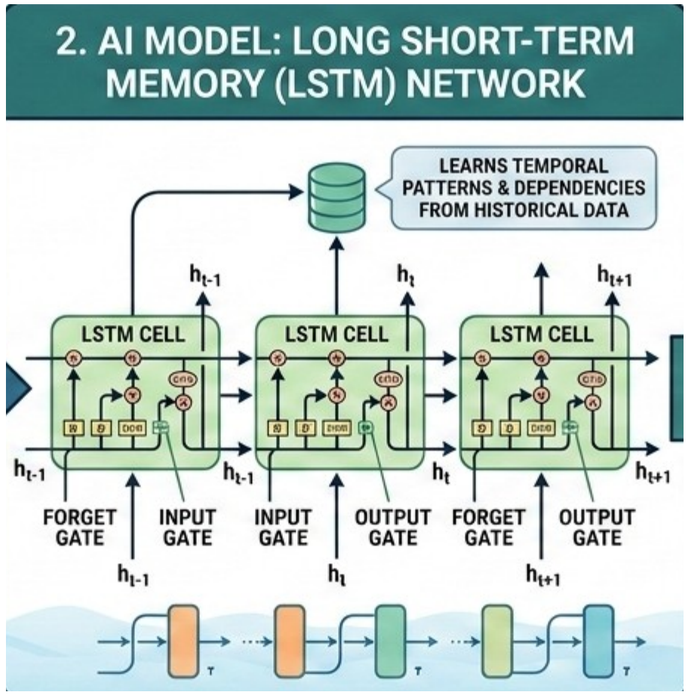
List of AOPs under WGH

	Projects	Driver	Duration
AOP1	Knowledge Sharing on Storm Surge Inundation Mapping	USA	2020~2027
AOP2	Improvement of **Hydrological Data Quality Control System** by using AI Technology	ROK	2023-2027
AOP3	Improvement of **Flood Forecasting Modelling** by using AI Technology	ROK	2023-2027
AOP4	Review on Specifications for Hydrological Information and Forecasting in TC Members	China	2025~2027
AOP5	Application Study on New Generation of Integrated Micro-Siphon Rain Gauge in TC Members	China	2025~2027
AOP6	Flood Risk Mapping with Ground/Satellite Observation Data	Japan	2024~2027
AOP7	Flood Resilience Enhancement through Platform on Water Resilience and Disasters	Japan	2023~2027
AOP8	Training Course on Hydrological Monitoring and Flood Management for Developing Countries	China	2023~2028
AOP9	Synergized Standard Operating Procedures for Coastal Multi-Hazard Early Warning System (SSOP)-Phase III	USA	Suspended

AI technique used for QC and Flood Forecasting

Hydrological Data Quality Control + Flood Forecasting





AI Flood Forecasting

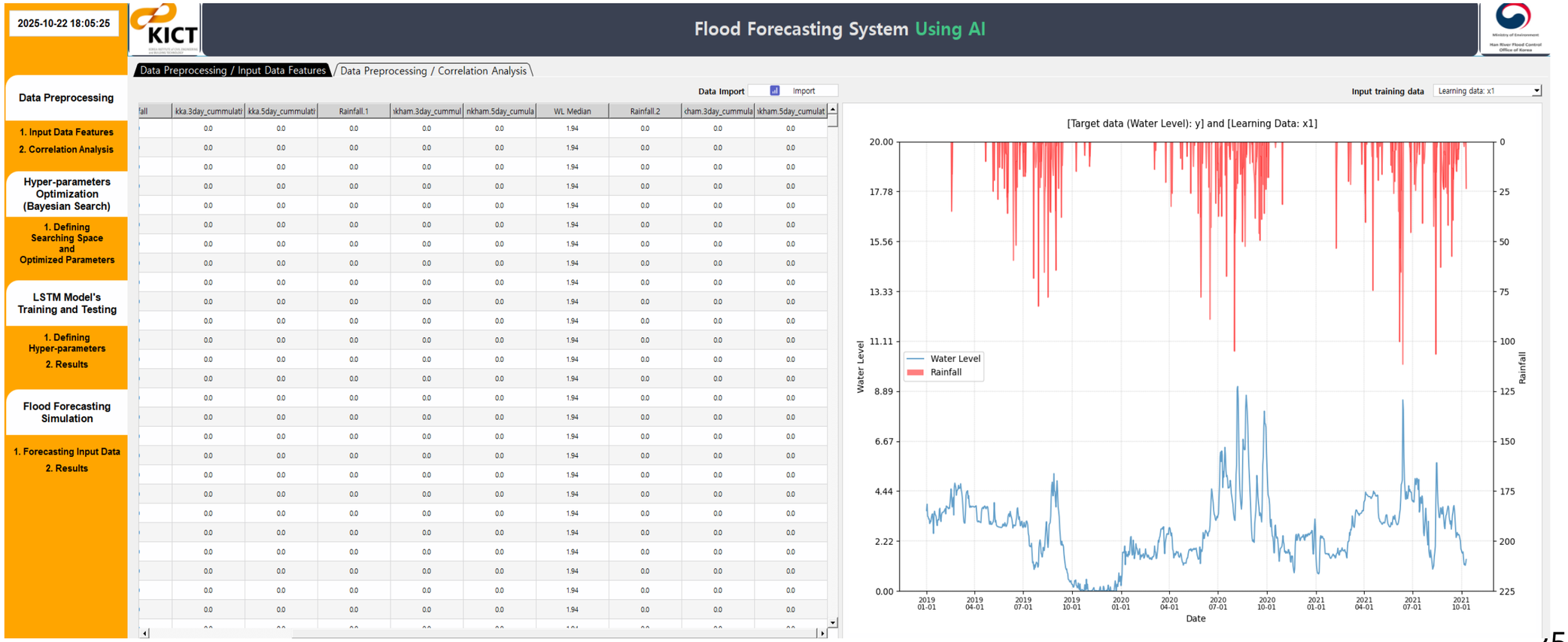
[Module1] Data preprocessing

Data Preprocessing Module

Hyper-parameters Optimization Module

LSTM Model's Training & Testing Module

Flood Forecasting Simulation Module



AI Flood Forecasting

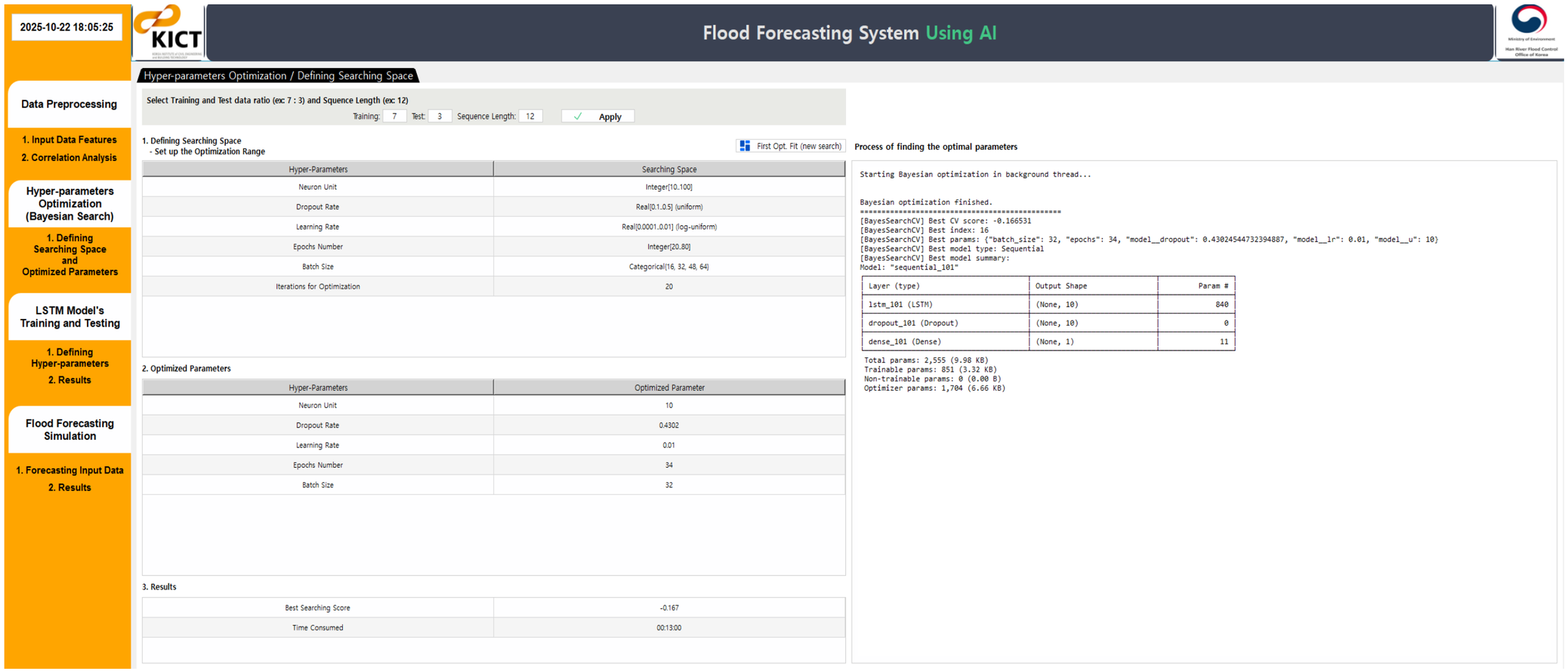
[Module2] Hyper-parameters Optimization

Data Preprocessing Module

Hyper-parameters Optimization Module

LSTM Model's Training & Testing Module

Flood Forecasting Simulation Module



AI Flood Forecasting

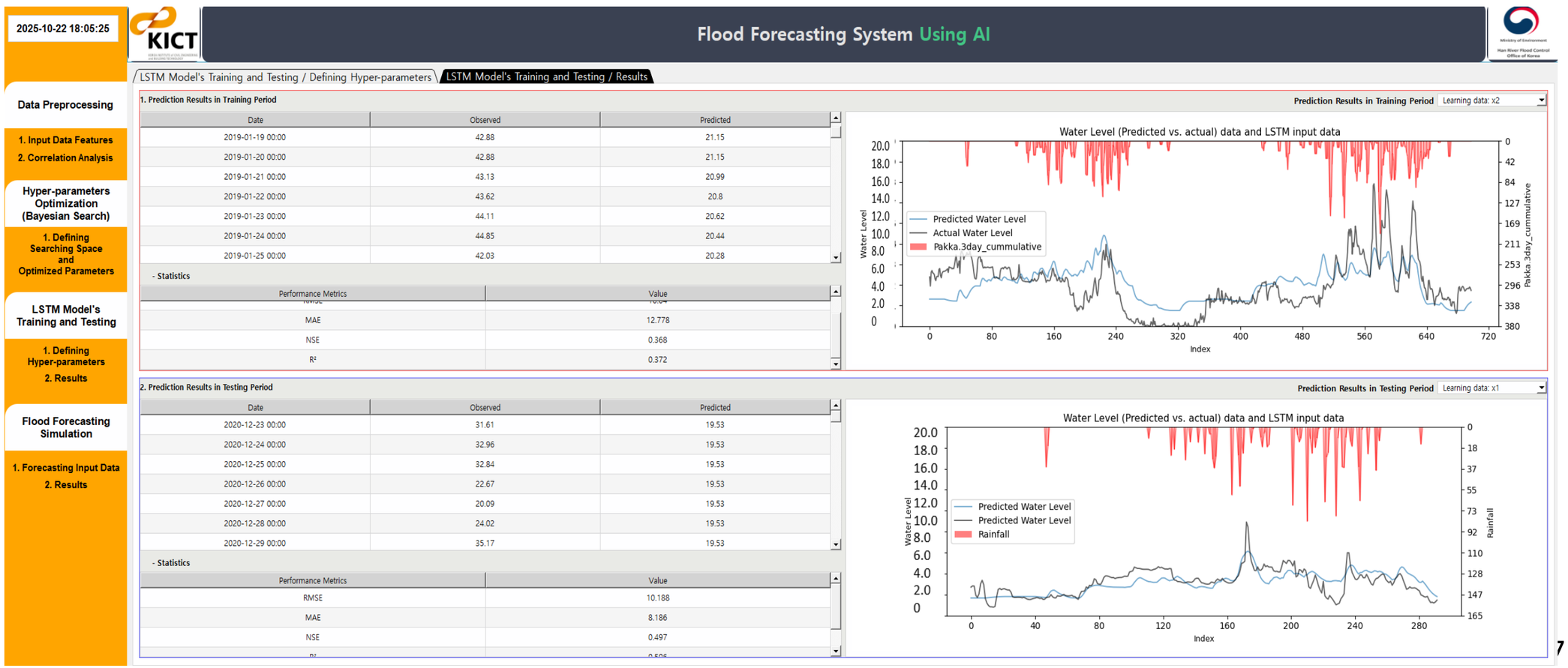
[Module3] LSTM Model's Training & Testing

Data Preprocessing Module

Hyper-parameters Optimization Module

LSTM Model's Training & Testing Module

Flood Forecasting Simulation Module



AI Flood Forecasting

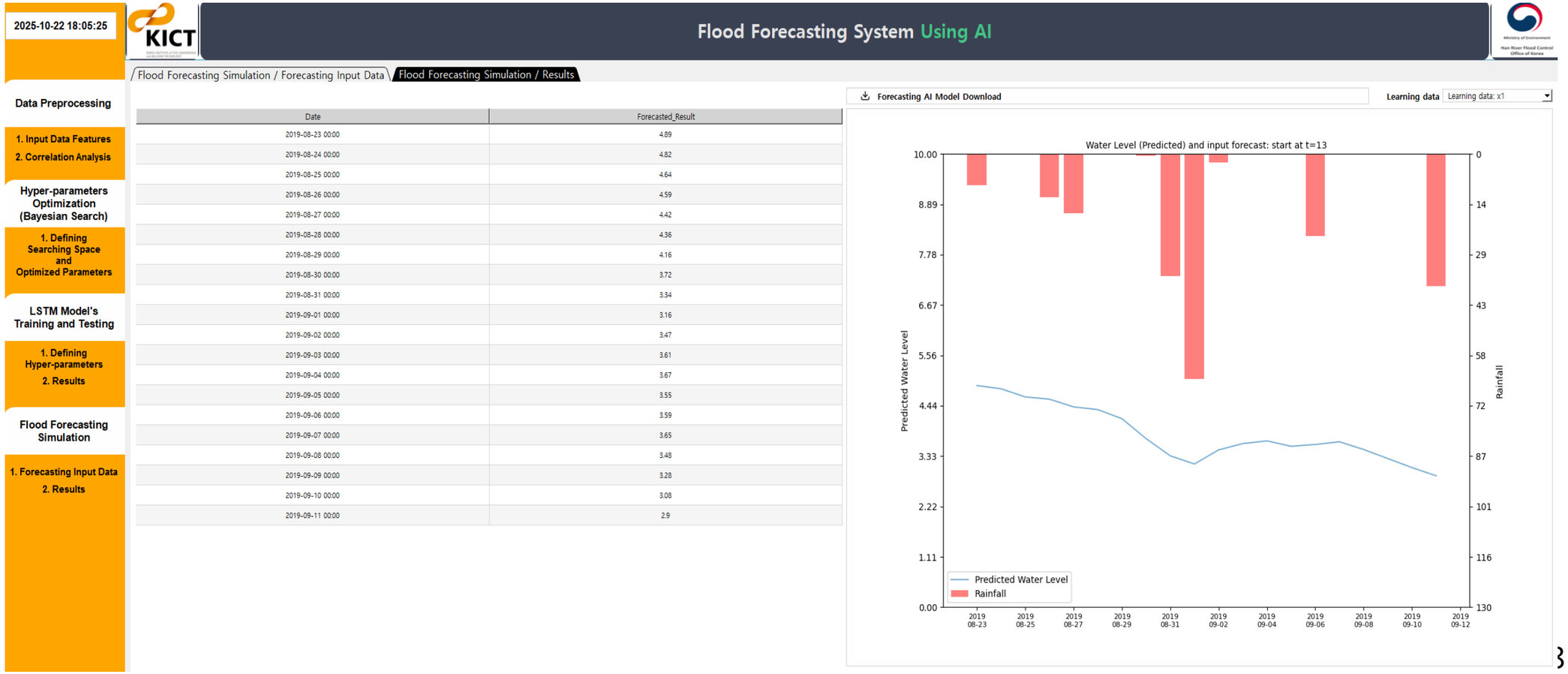
[Module4] Flood Forecasting Simulation

Data Preprocessing Module

Hyper-parameters Optimization Module

LSTM Model's Training & Testing Module

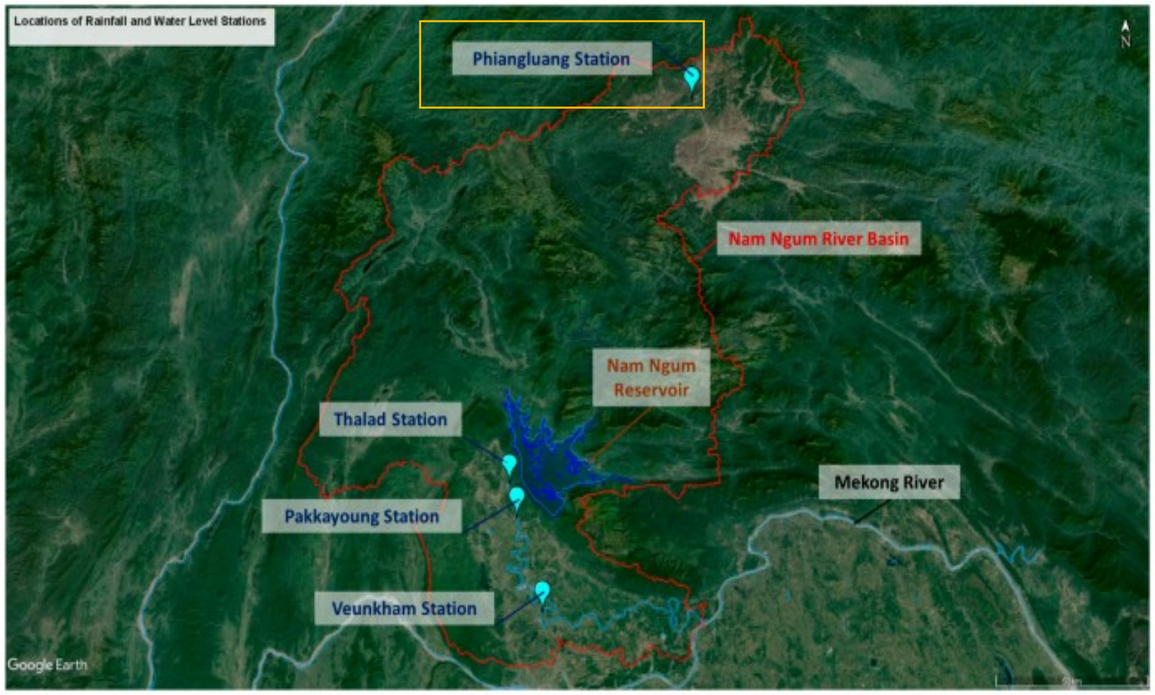
Flood Forecasting Simulation Module



AI Flood Forecasting

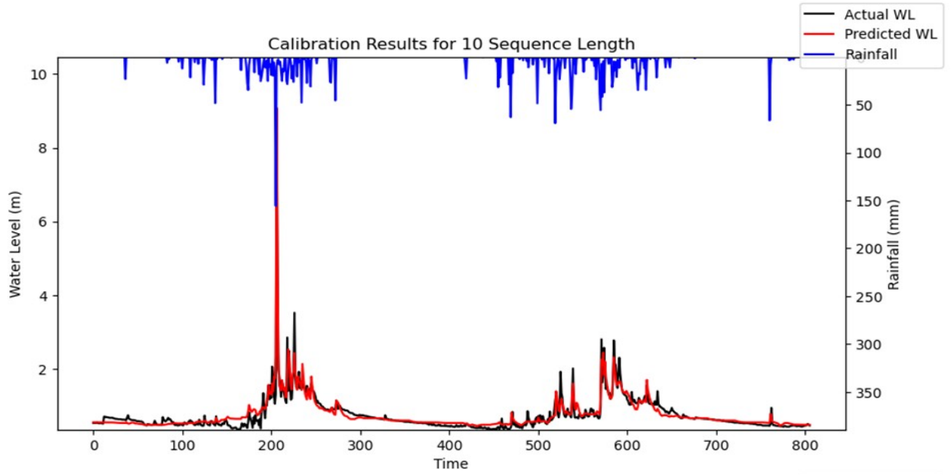
Pilot Application: Lao. P.D.R

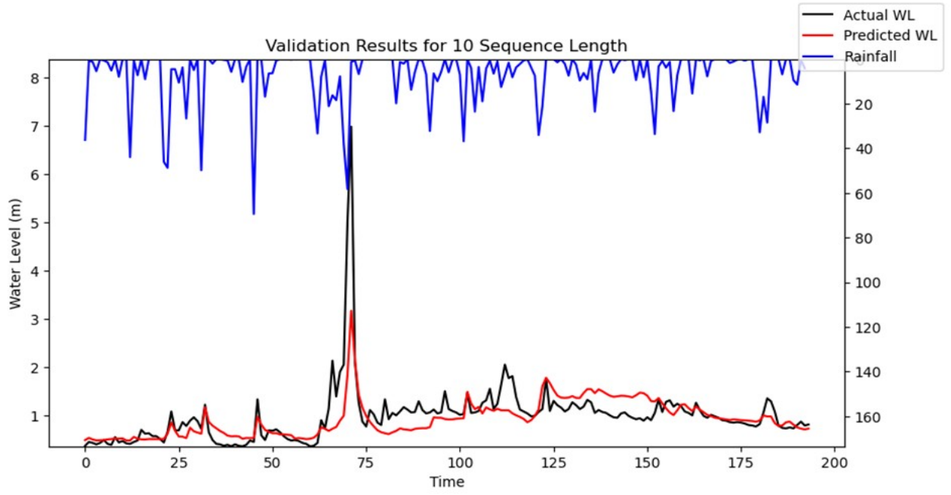
Data Period: Jan 2019 - Oct 2021 (About 3 years, 70% training, 30% testing)
Input Data: Daily rainfall, 3-day, 5-day, 7-day cumulative rainfall, and monthly average water level at Phiangluang station
Target Data: Daily water level at Phiangluang station



Nam Ngum river basin in Lao P.D.R
(Target station: Phiangluang station)

성능 지표	Training	Testing
RMSE	0.155	0.462
NSE	0.903	0.471
R^2	0.905	0.491
MAE	0.099	0.247

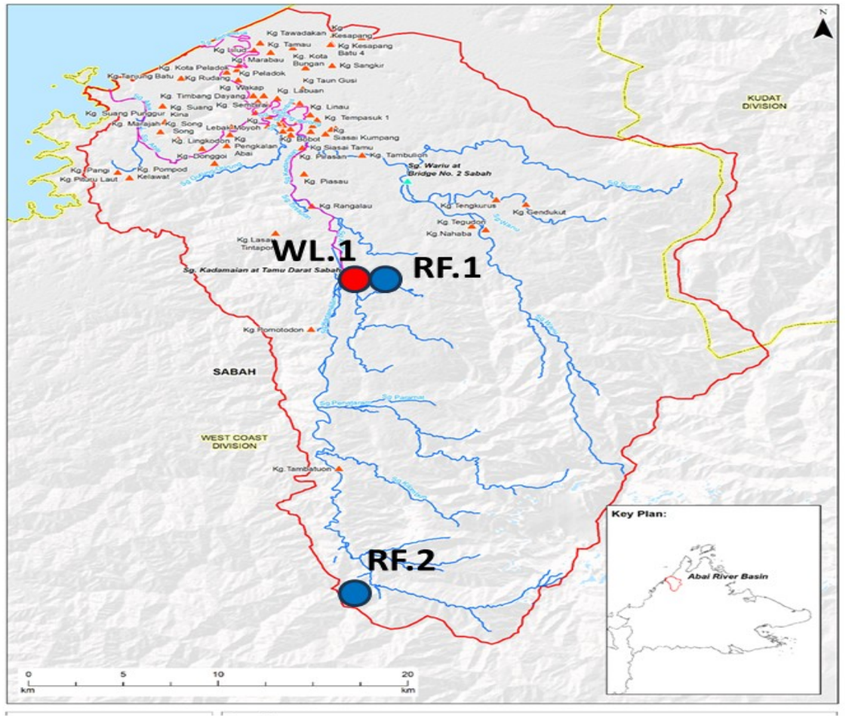




AI Flood Forecasting

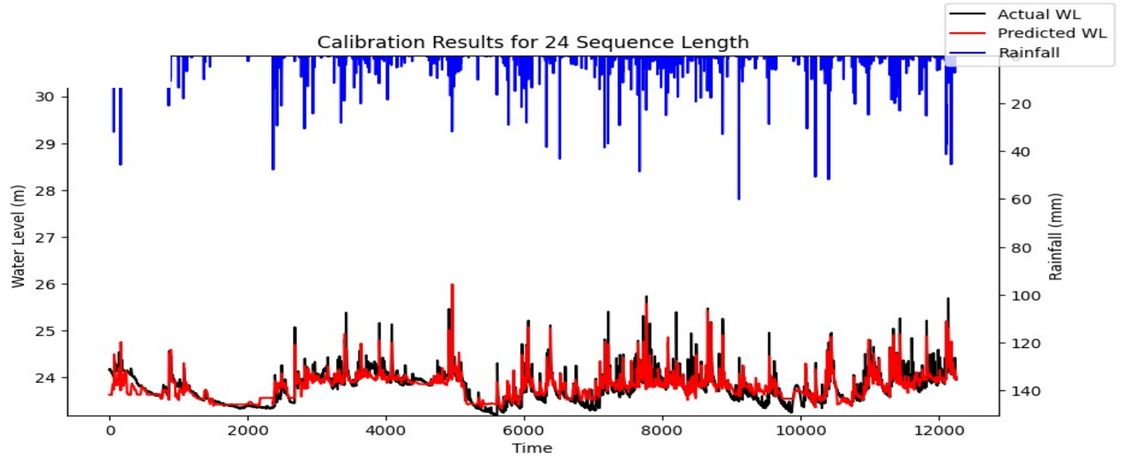
Pilot Application: Malaysia

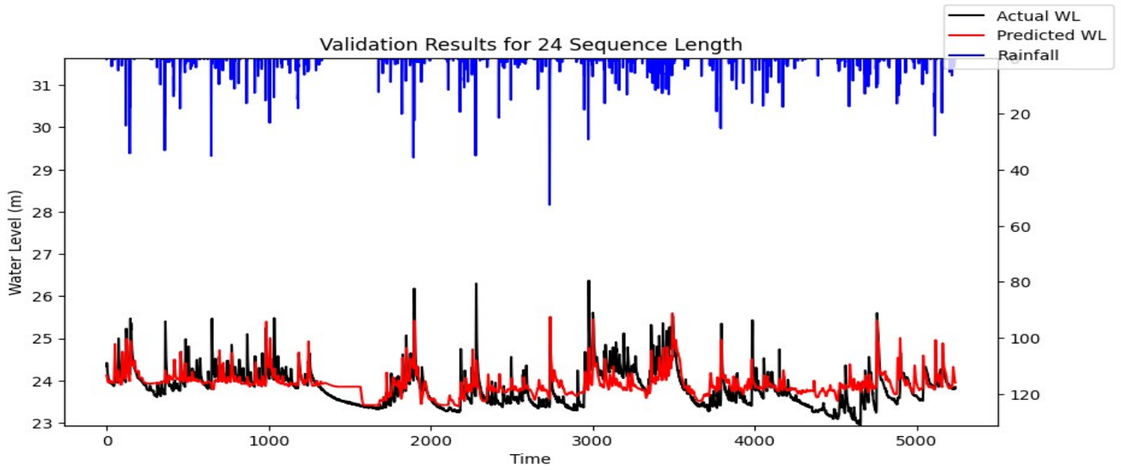
Data Period: Jan 2016 - Dec 2017 (2 years, 70% training, 30% testing)
Input Data: Hourly rainfall, 24-hour, 48-hour, 72-hour cumulative rainfall, and monthly average water level at Tamu Darat station
Target Data: Hourly water level at Tamu Darat station



Abai river basin in Malaysia
(Target station: Tamu Darat station)

성능 지표	Training	Testing
RMSE	0.149	0.310
NSE	0.779	0.480
R^2	0.788	0.526
MAE	0.112	0.243

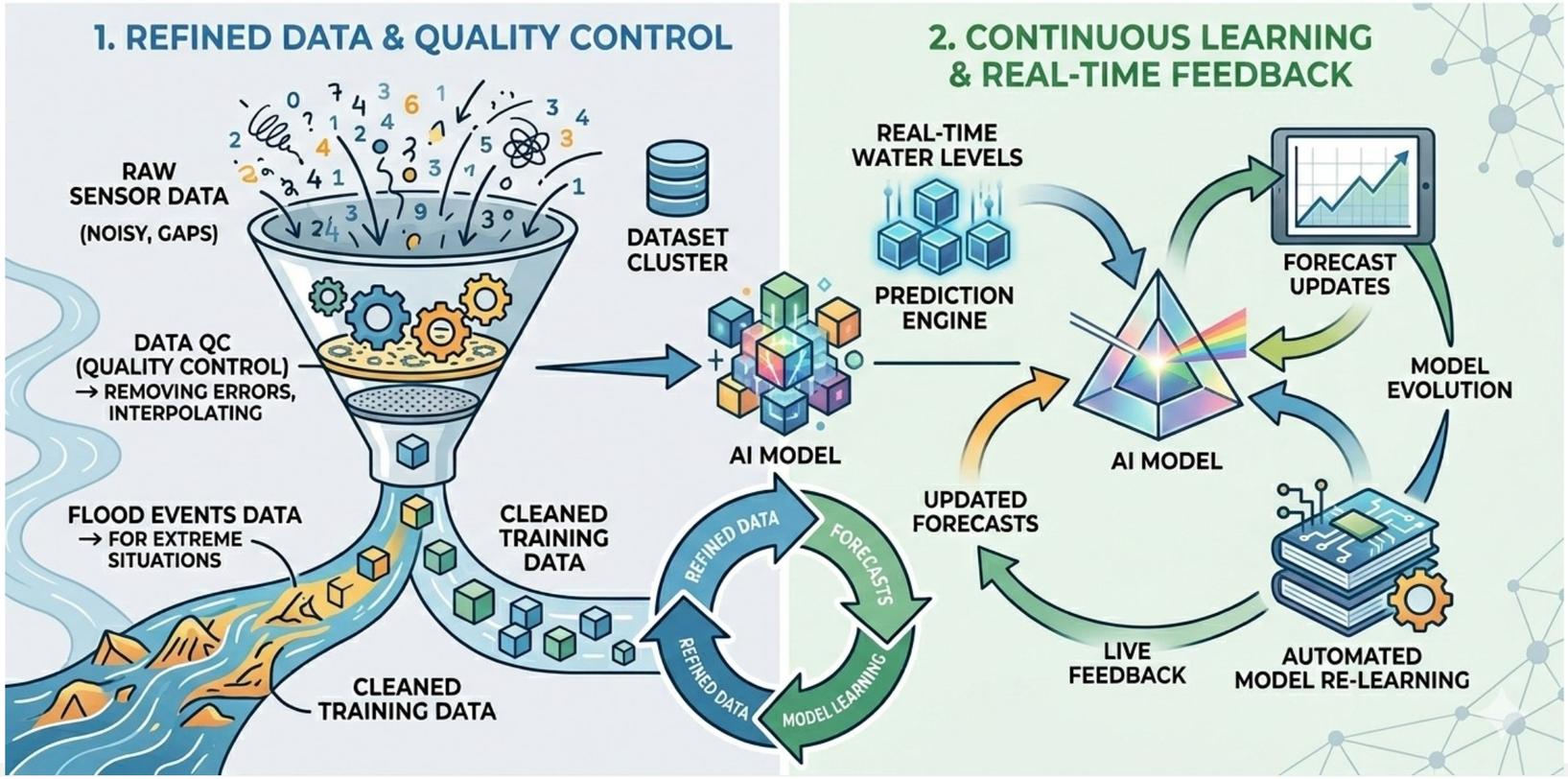




Conclusion

Conclusion

- Performance of river flood forecasting using AI: Suitable for service
- Refined data: Data QC and Training data including flood events
- Continuous Learning: Real-time data feedback and relearning



THANK YOU

Ministry of Climate, Energy and Environment

Han River Flood Control Office