

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

The Republic of Korea

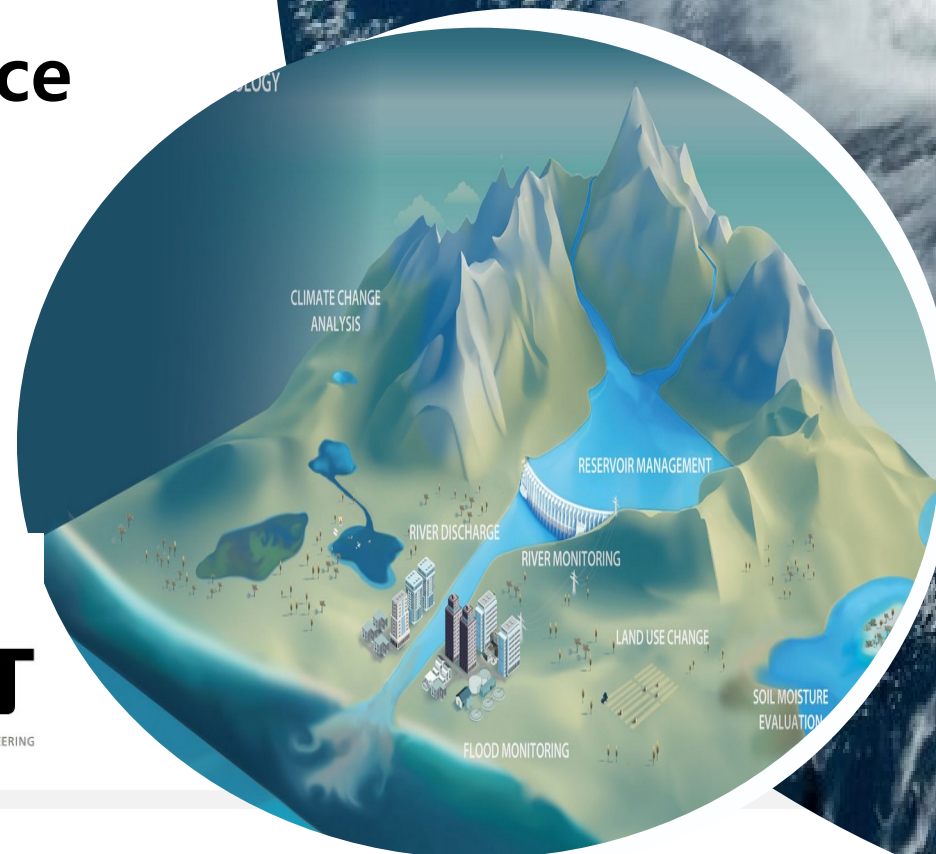
Yohan CHO
Han River Flood Control Office

58th Typhoon Committee session

10-13 March 2026, Jeju



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



Contents

1. Overview

2. AI Flood Forecasting System

3. Achievements and Management

4. International cooperation

5. Conclusions



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Overview

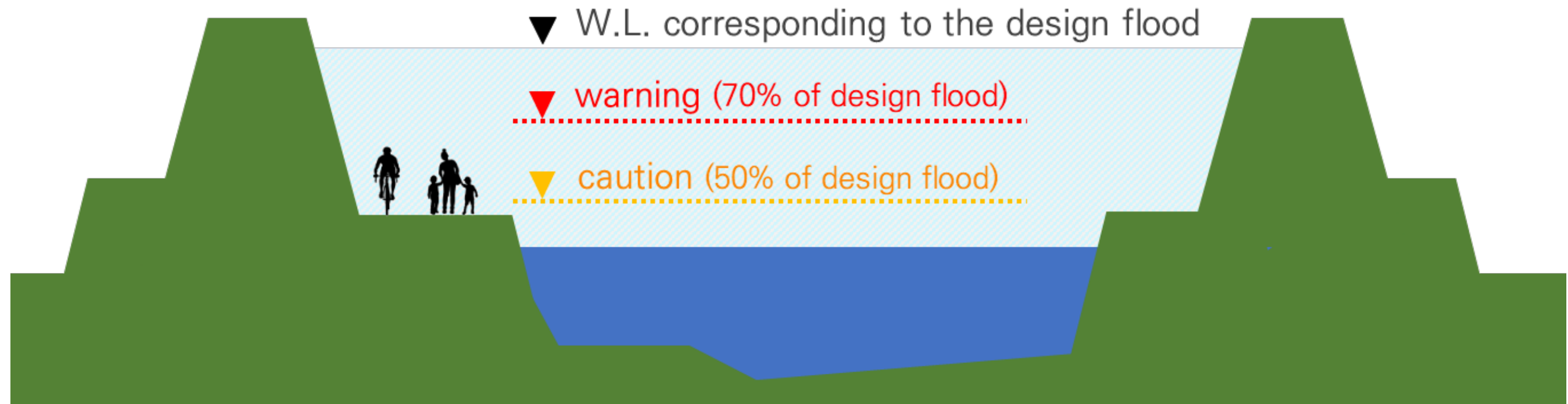
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Flood Warning in Korea

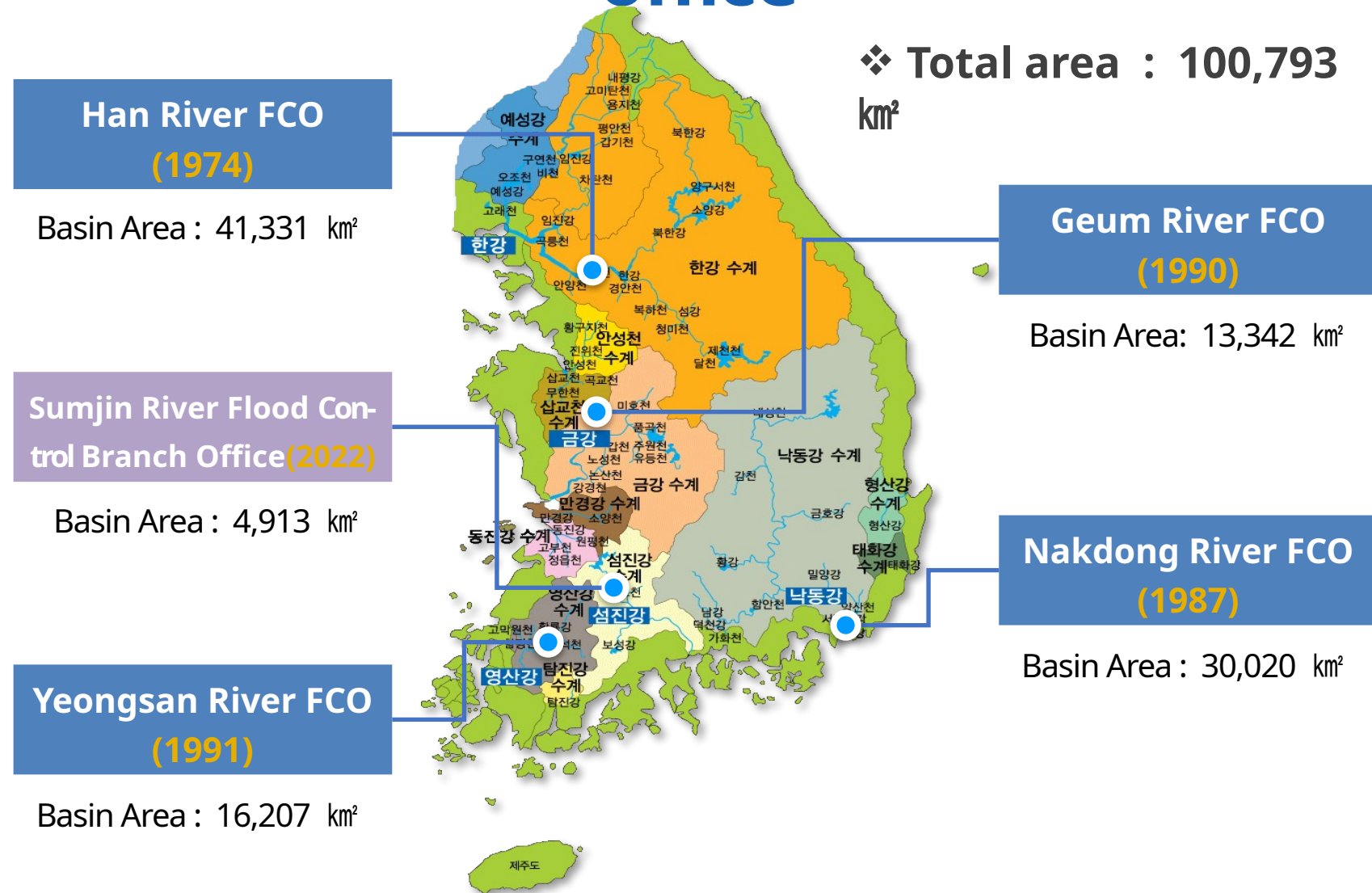
When is an Flood Warning issued?

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







Main missions

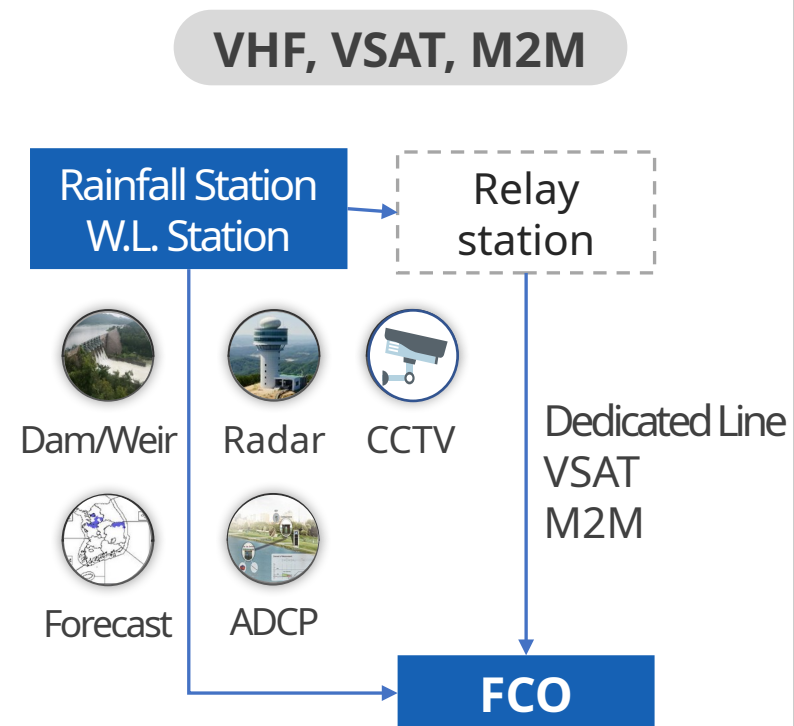
- Water resources survey**
 Hydrologic survey, river basin investigation, flood and drought damage survey
- Forecasting for flood and low flow**
 High and low flow control and management, Approval for discharge of dam and weir
- Flow management in river**
 linked operation dam and weir, permission of 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.
 * 100 planned by 2029
- 
933 Water level Stn.
 * 238 constructed in 2024
- 
Runoff survey
 * 80 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.

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AI Flood Forecasting System

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Introduction of AI for Flood Forecasting

Background

Lack of forecasting system for small rivers

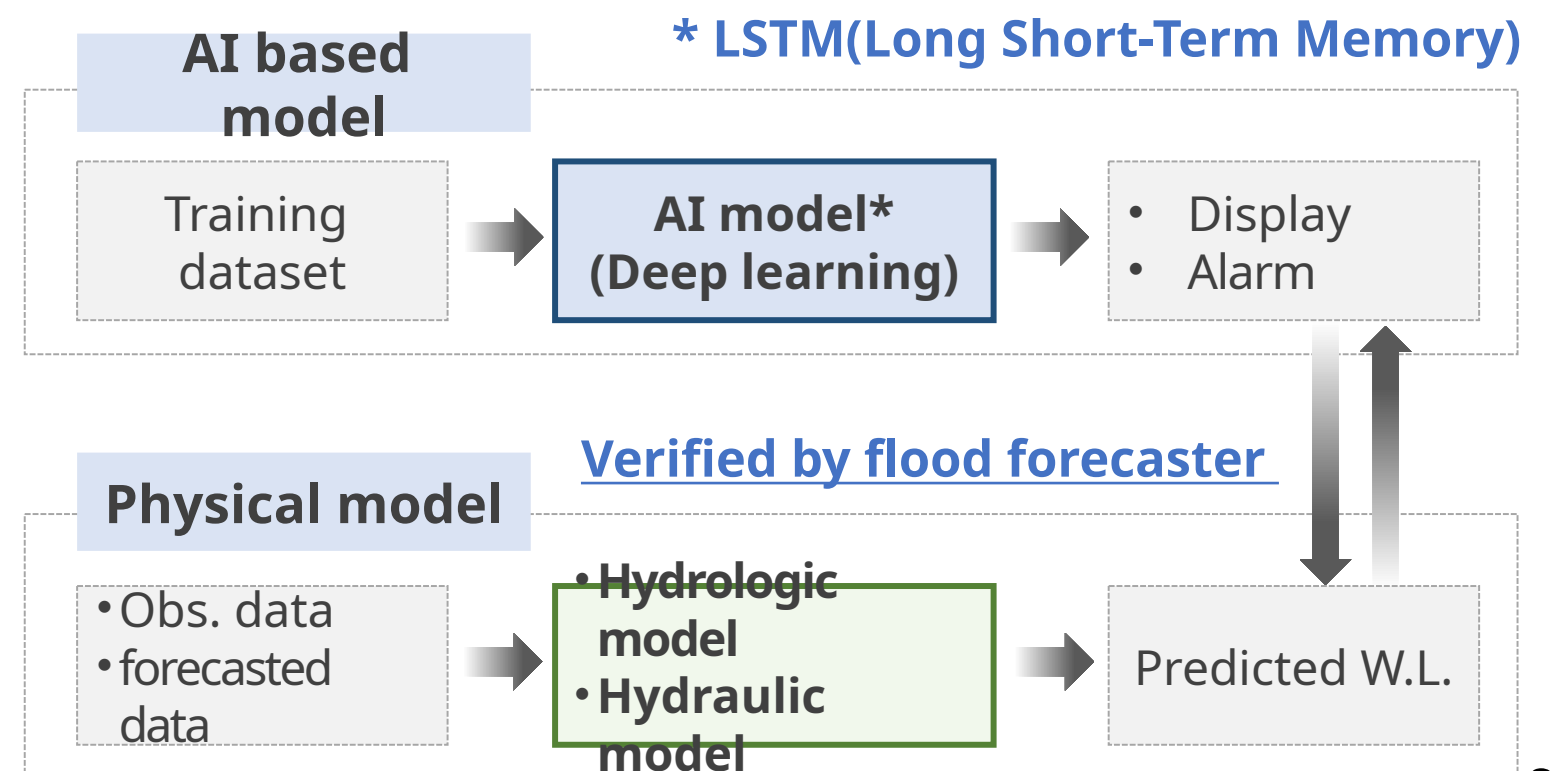
- Increased heavy rain frequency and rainfall due to climate change
- ➔ Damages in local (small) rivers more than damages in national (large) rivers

Need to improve forecasting method

- Flood forecasting and issuing by manpower
- ➔ Difficult to increase the number of flood forecasting stations

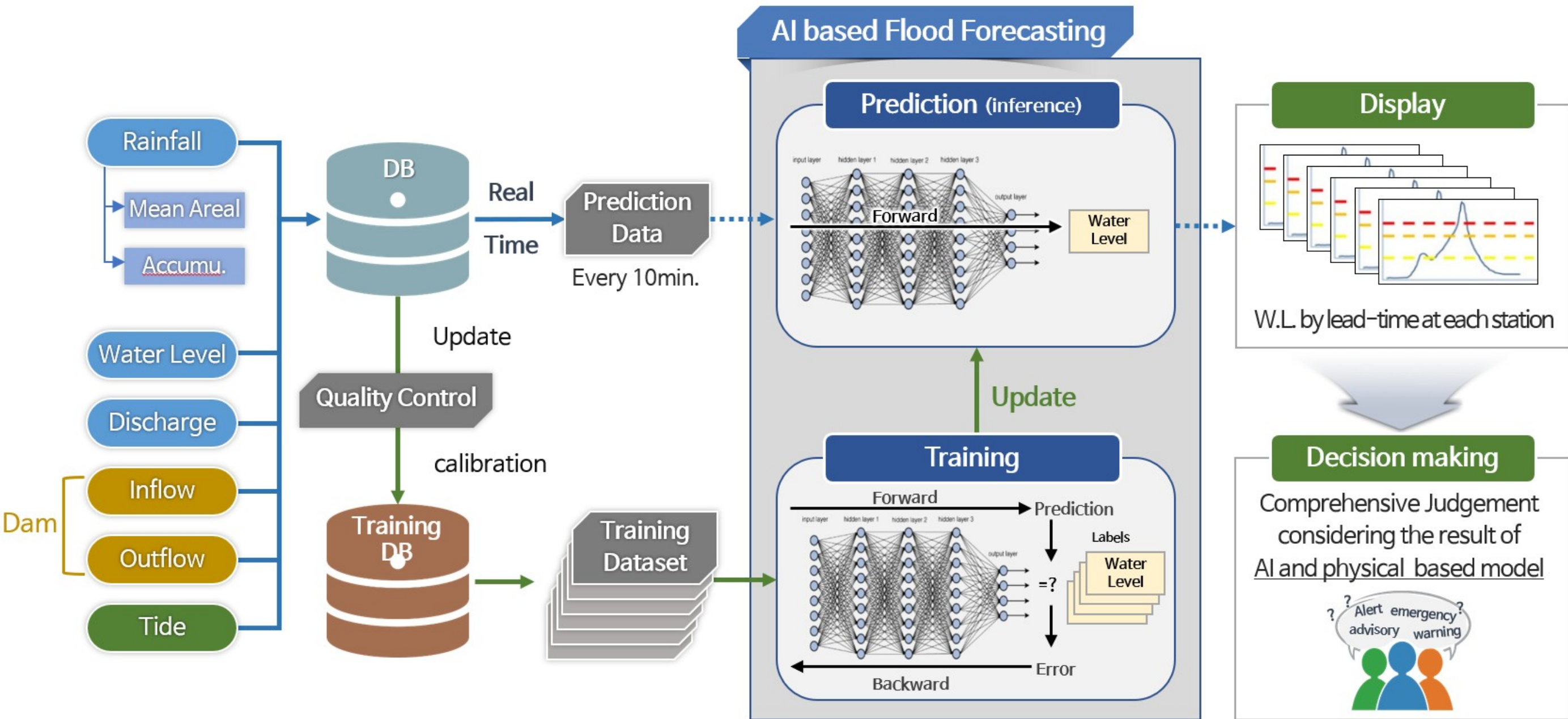
Improving the forecasting system

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



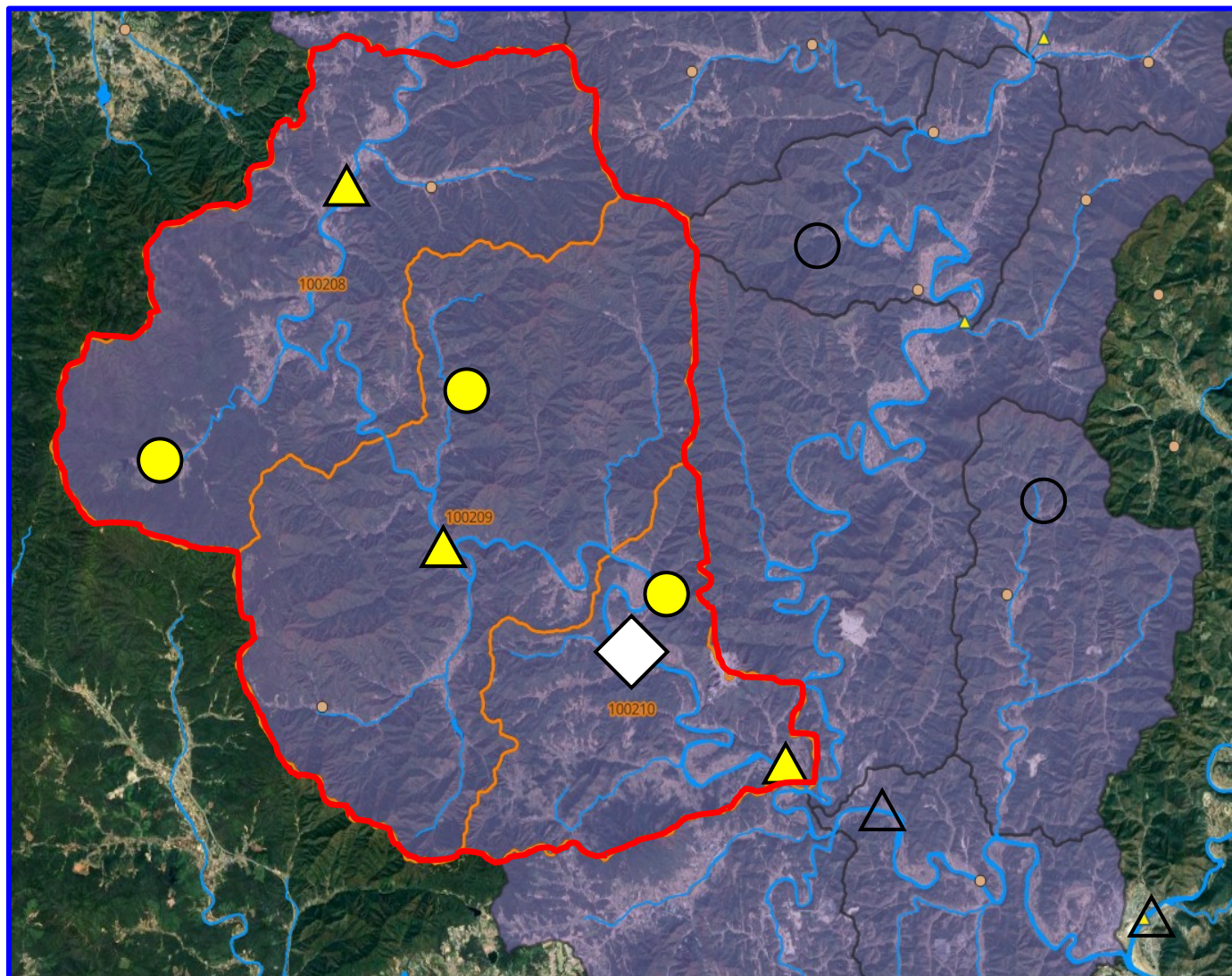
AI Model Building Process

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

The screenshot displays the AI Flood Forecasting System interface. On the left, there are navigation menus for '전국' (National), '한강' (Han River), '낙동강' (Nakdong River), '금강' (Geum River), '영산강' (Yeongsan River), '기상영상' (Weather Video), '기상특보' (Weather Special Report), and '태풍' (Typhoon). The main area shows a map of South Korea with various flood risk indicators. A red arrow points to a specific station on the map, which is highlighted with a green circle. Another red arrow points to a detailed data table for that station.

홍수특보지점	하천명	하천등급	홍수특보 발령현황	홍수특보 기준수위 (m)	주의보(m)	현재수위 (m)	10분전
보령시(노천교) [2]	웅천천	국가	주의보	4.80	3.80	2.78	2.86
정선군(송천교) [4]	송천	지방		4.70	3.60	0.83	0.84
정선군(제1여량교) [2]	골지천	지방		6.50	5.20	1.49	1.50
정선군(남평대교) [2]	한강	국가		6.50	5.50	1.84	1.84
정선군(나천교) [2]	오대천	지방		5.00	4.00	1.13	1.13
정선군(와평교) [4]	어천	지방		4.50	4.00	1.47	1.47
정선군(정선제1교) [2]	한강	국가		6.00	4.50	-0.17	-0.17
정선군(낙동교) [2]	지장천	지방		3.50	3.00	1.37	1.36
영월군(영월대교) [4]	한강	국가		8.00	6.00	0.79	0.79
평창군(사초교) [4]	대화천	지방		4.50	4.00	2.03	2.02
평창군(평창교) [2]	평창강	국가		6.20	4.60	0.11	0.11
영월군(주천교) [4]	주천강	국가		6.00	5.00	1.21	1.20
				6.50	5.50	0.41	0.41
				4.60	4.00	1.70	1.69
				5.00	4.00	0.47	0.47
				4.50	4.00	1.22	1.22
				5.50	4.50	2.28	2.29
				3.50	3.00	1.26	1.26
				6.10	5.20	0.79	0.78
				6.00	5.00	1.07	1.07
				4.70	3.90	2.21	2.22
				3.40	2.50	0.29	0.29
				5.80	4.60	1.37	1.35
				3.90	3.20	1.34	1.32
				6.50	5.50	1.42	1.40

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

AI홍수예보시스템

유출모식도

A

수계선택

홍수기설정

유역강우량산정

홍수유출량계산

하도홍수위계산(FLDWAV)

하도홍수위계산(HEC-RAS)

기타

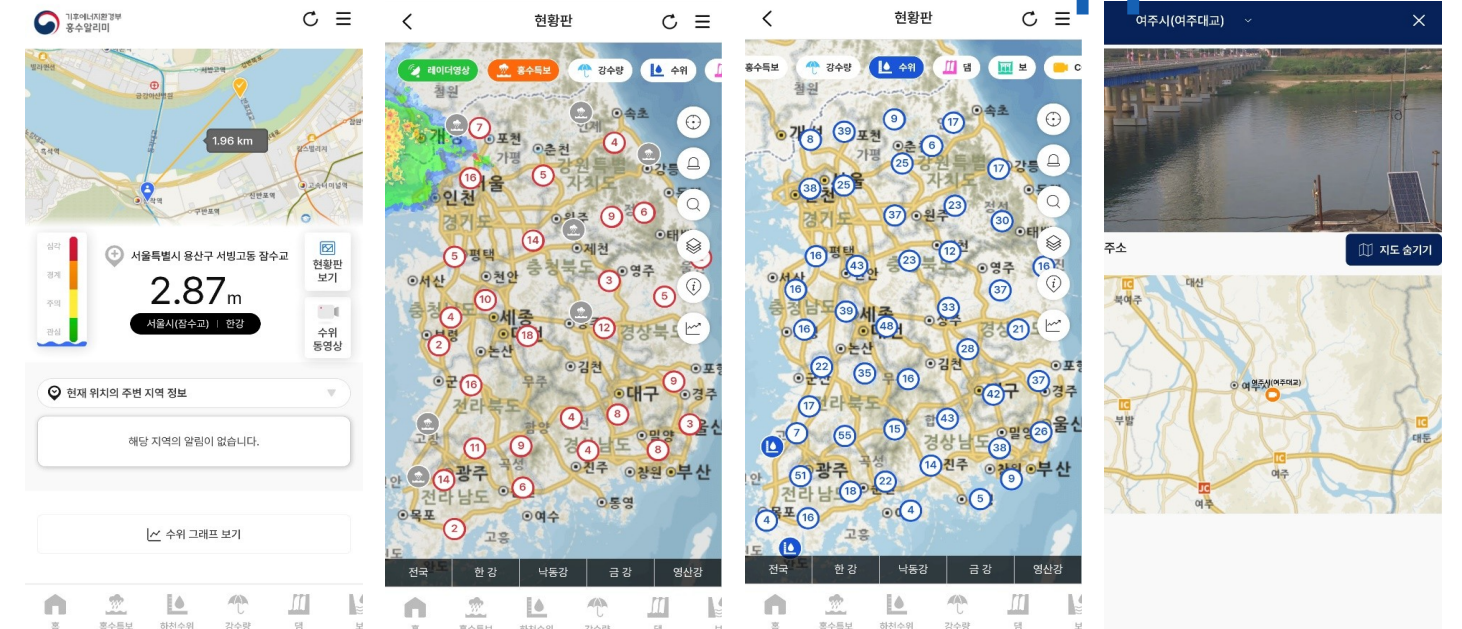
사용자명	사용자
선택수계	금강
홍수기 번호	20250701
홍수기 시작시간	2024-07-06 00:00
홍수기 종료시간	2024-07-16 00:00
홍수기 현재시간	2024-07-10 00:00
유역강우량	유역티센평균강우량
강우예측 사용	Y
강우예측 시작시간	2024-07-10 00:10
강우예측 종료시간	2024-07-10 06:00

Delivery of Flood Warnings

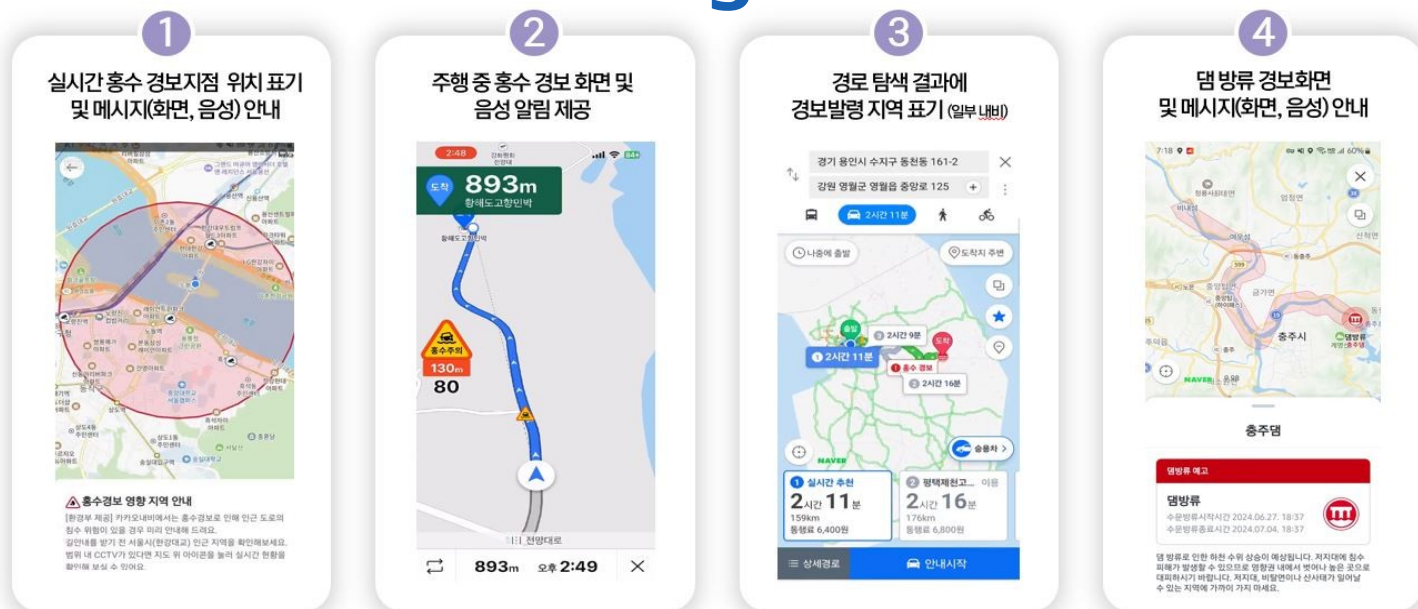
Flood information



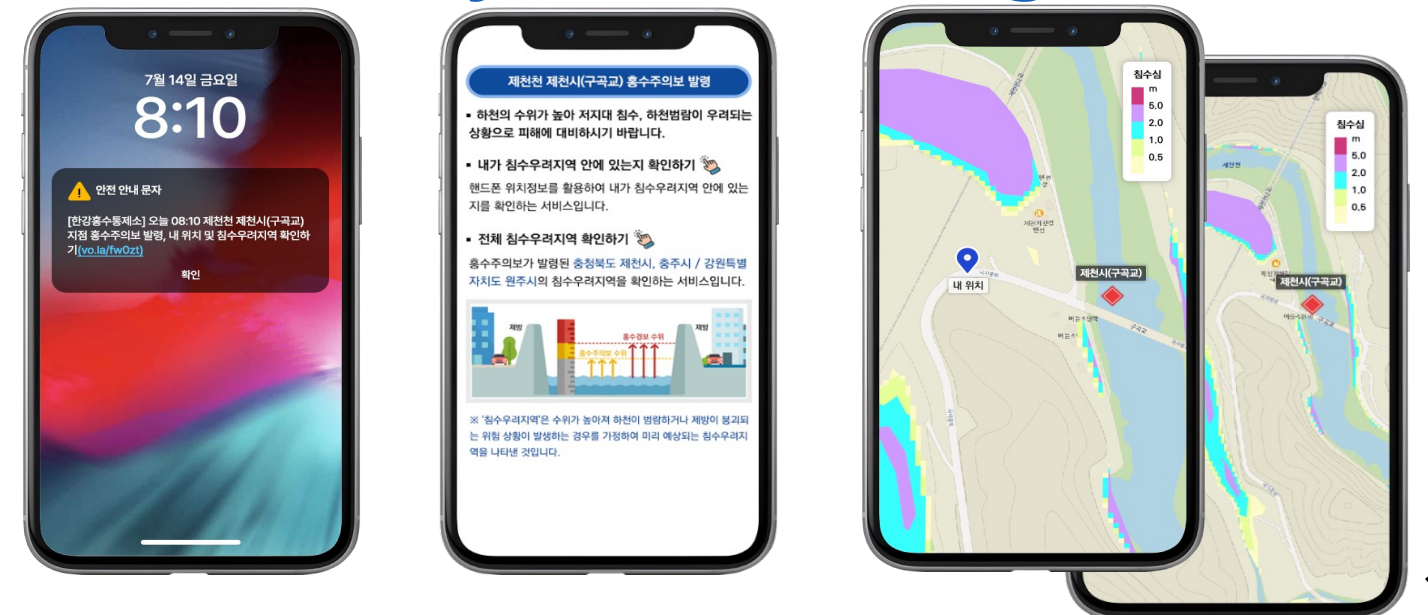
Flood information App.



Navigation



Safety Alert Message



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Achievements and Management

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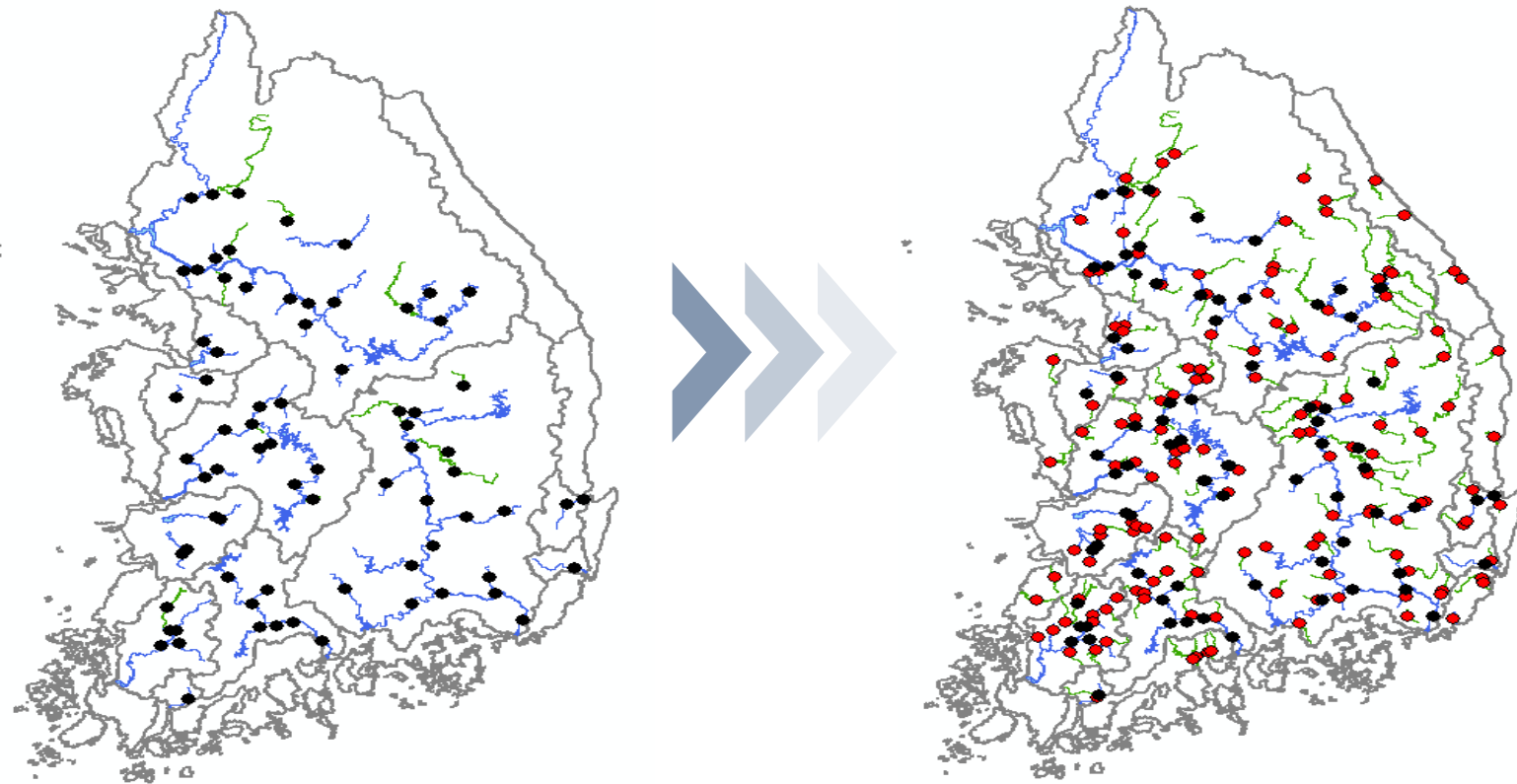


Increase in Flood Forecasting Stations and Warnings

[2023] 75 stations
 stations

[2024~] 223


National river 63 → 112 stations
 Local stream 12 → 111 stations



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 from 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

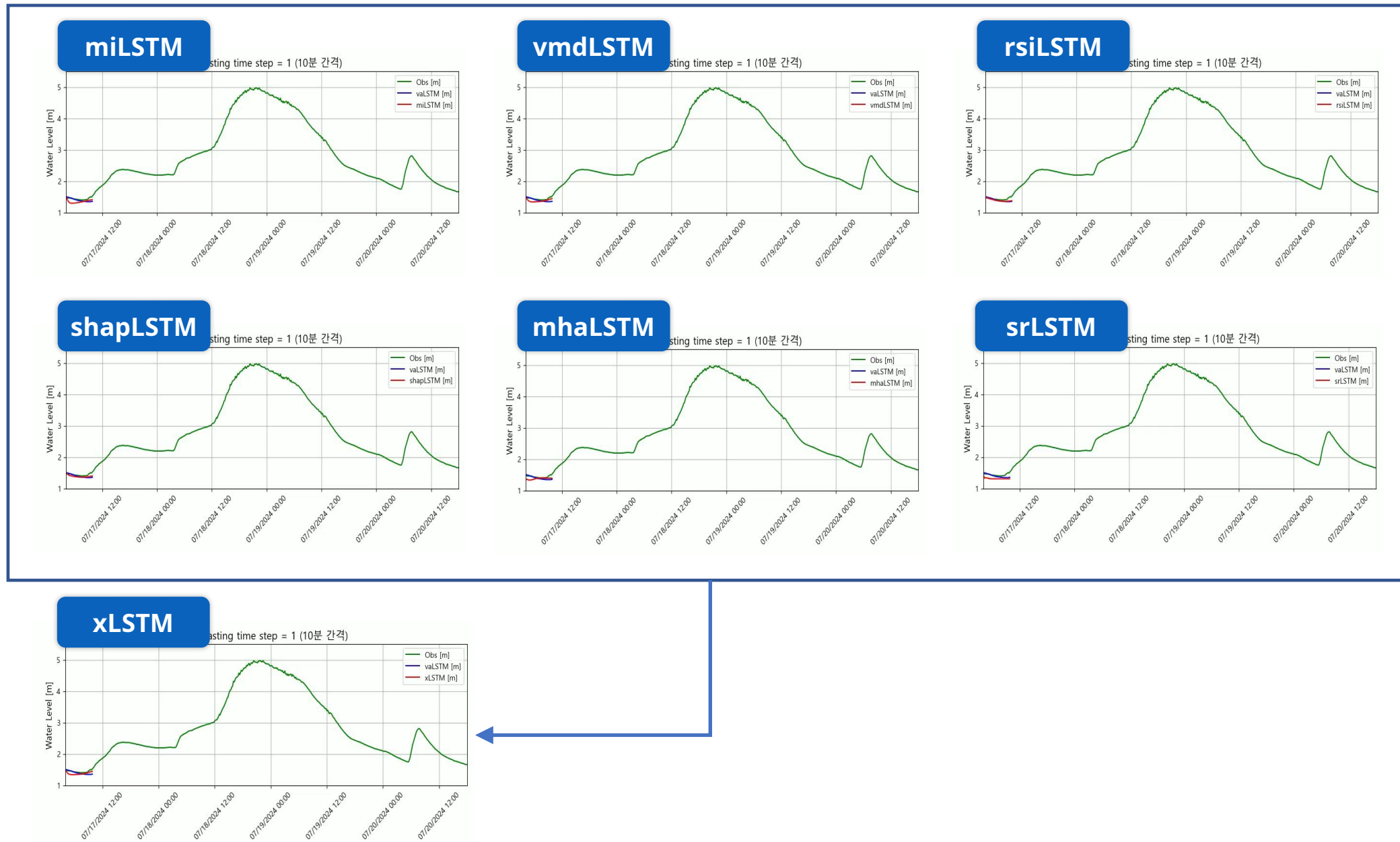
- Outlier removal to improve data quality
- Composition of learning materials with various scenarios such as floods and droughts
- Management of learning data and model version using MLOps (Machine Learning Operations)

- Selection of deep learning technique

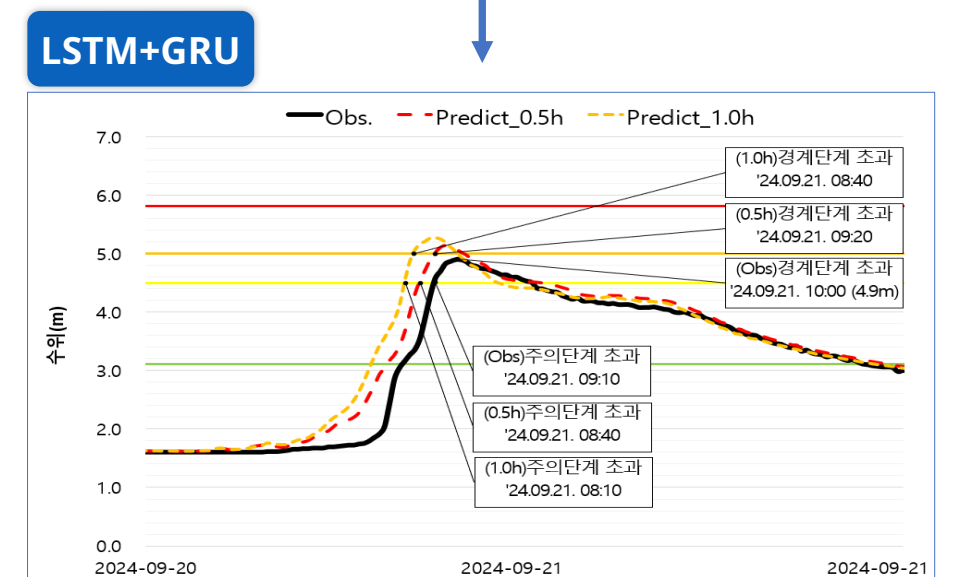
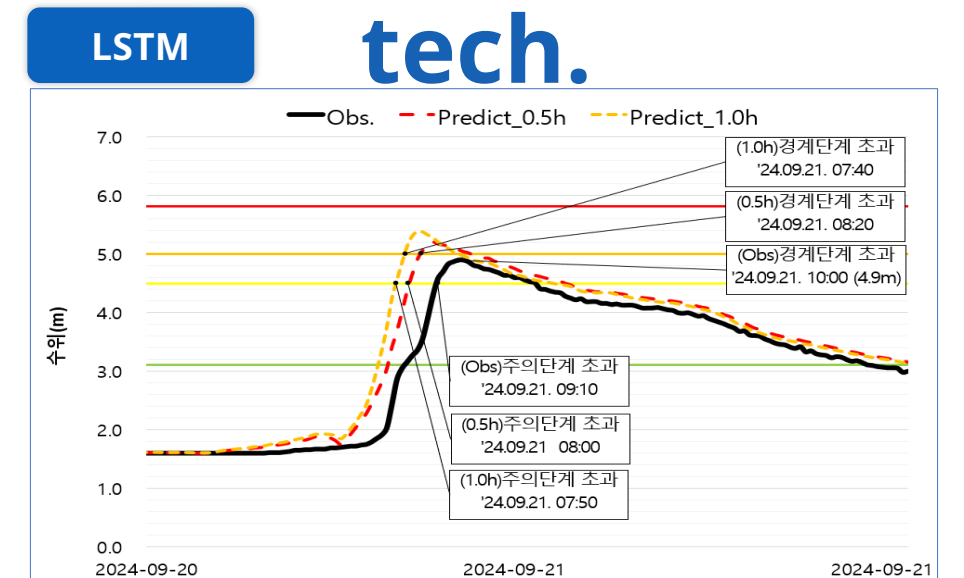
- LSTM has several variants depending on the data complexity, variable type, and prediction horizon.
- The choice of LSTM technique significantly affects not only prediction accuracy but also model efficiency (computational speed) and interpretability.

Improving Deep Learning Techniques

Improving current AI tech.



Reviewing new AI tech.



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International cooperation

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AOP led by ROK under Working Group

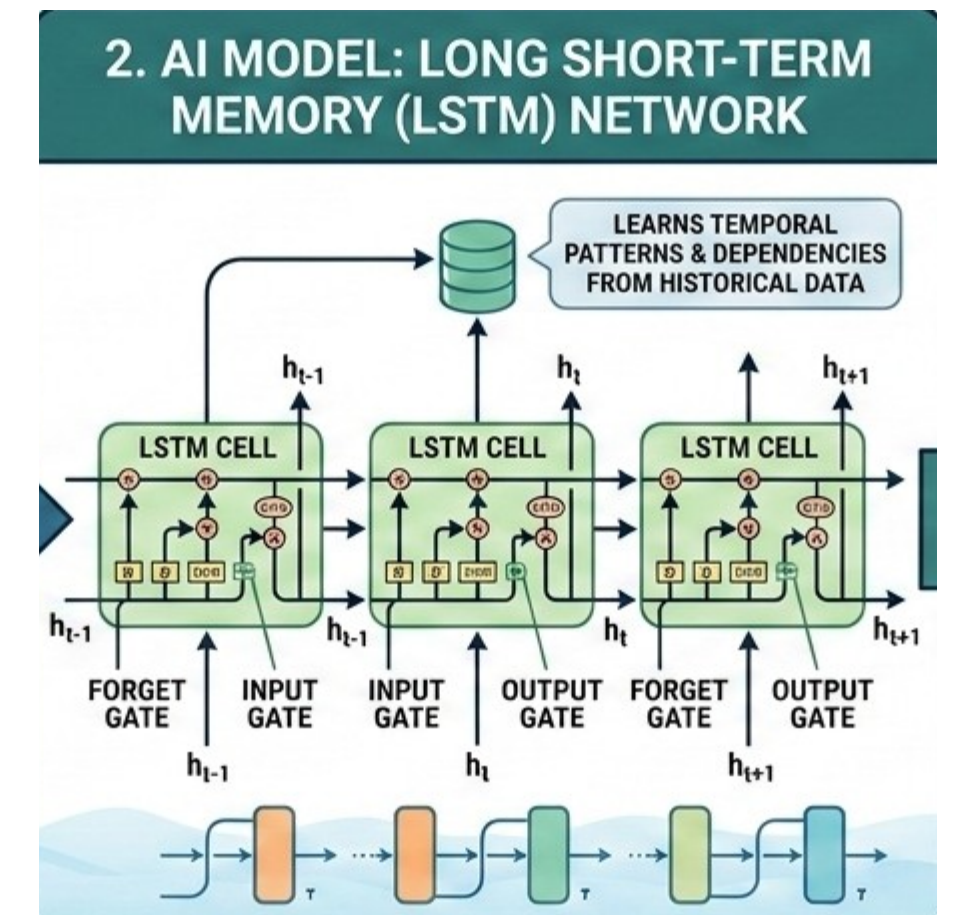
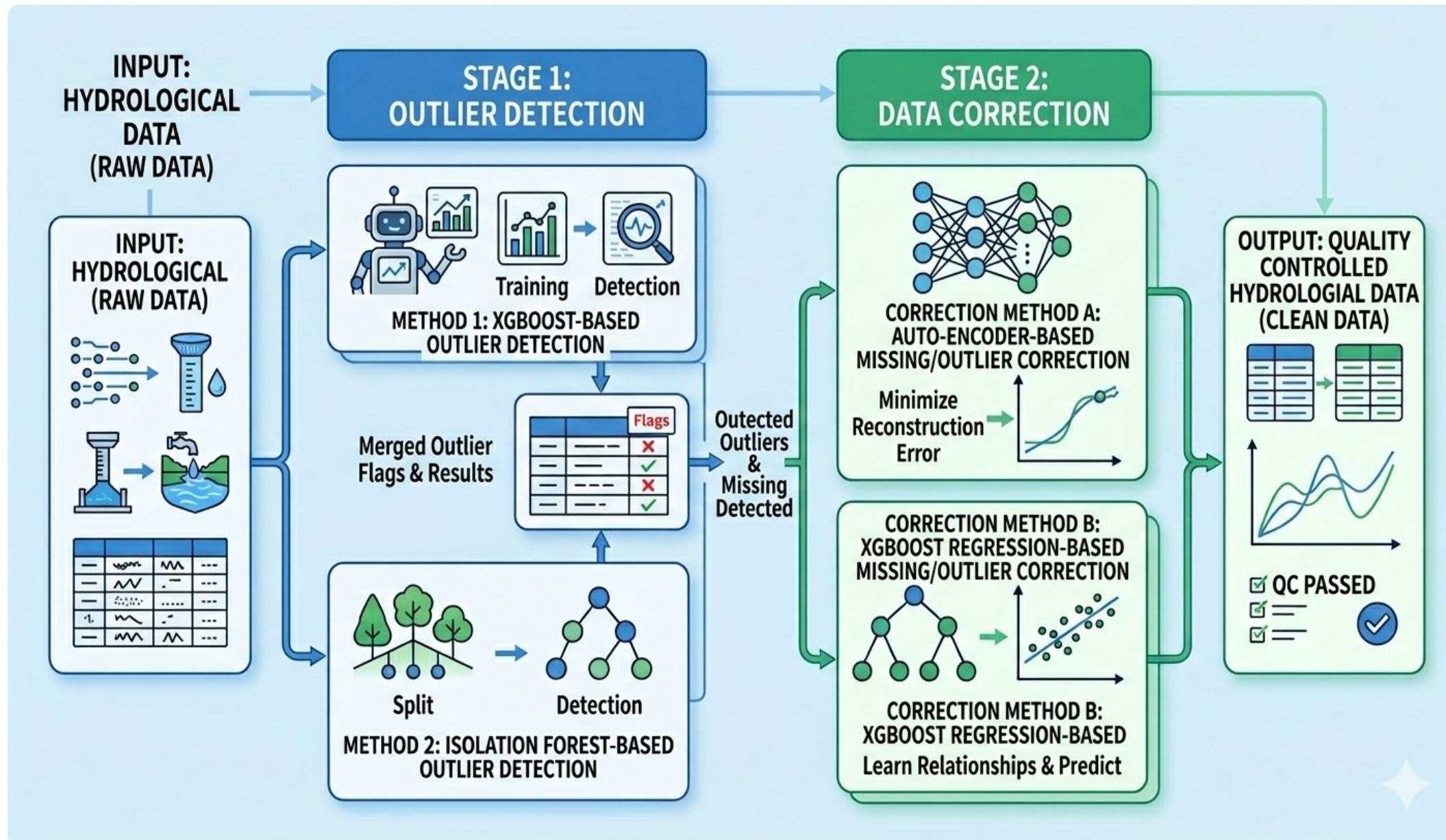
- Currently, there are TWO AOPs led by ROK under WGH, which are funded by HRFCO and conducted by KICT:
- 4 target member countries: **Lao P.D.R**, Malaysia, Philippines, and Thailand

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

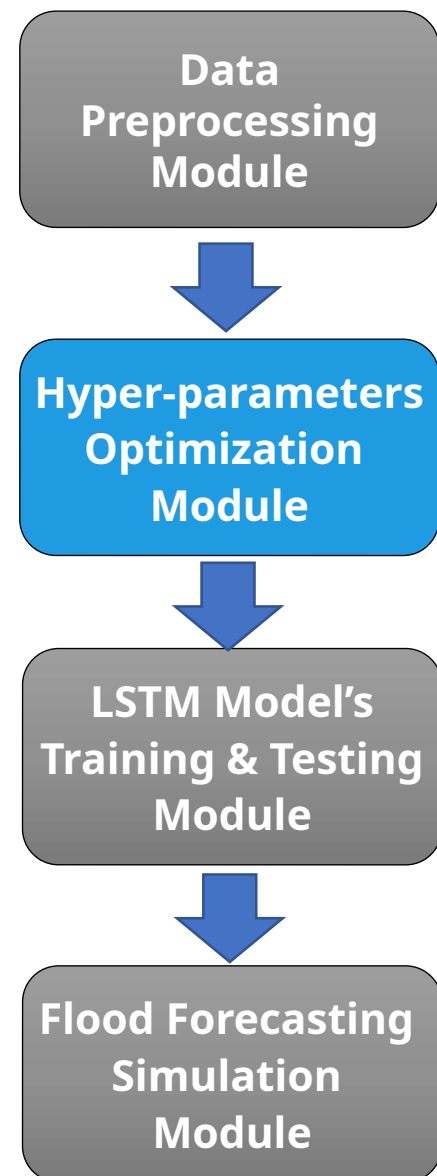
AI technique used for QC and Flood


Hydrological Data Quality Control + Flood Forecasting



AI Flood Forecasting


[Module2] Hyper-parameters Optimization





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Flood Forecasting System Using AI



Data Preprocessing

1. Input Data Features
2. Correlation Analysis

Hyper-parameters Optimization (Bayesian Search)

1. Defining Searching Space and Optimized Parameters

LSTM Model's Training and Testing

1. Defining Hyper-parameters
2. Results

Flood Forecasting Simulation

1. Forecasting Input Data
2. Results

Hyper-parameters Optimization / Defining Searching Space

Select Training and Test data ratio (ex: 7 : 3) and Sequence Length (ex: 12)

Training: Test: Sequence Length:

1. Defining Searching Space
- Set up the Optimization Range

Hyper-Parameters	Searching Space
Neuron Unit	Integer[10..100]
Dropout Rate	Real[0.1..0.5] (uniform)
Learning Rate	Real[0.0001..0.01] (log-uniform)
Epochs Number	Integer[20..80]
Batch Size	Categorical[16, 32, 48, 64]
Iterations for Optimization	20

2. Optimized Parameters

Hyper-Parameters	Optimized Parameter
Neuron Unit	10
Dropout Rate	0.4302
Learning Rate	0.01
Epochs Number	34
Batch Size	32

3. Results

Best Searching Score	-0.167
Time Consumed	00:13:00

Process of finding the optimal parameters

Starting Bayesian optimization in background thread...

Bayesian optimization finished.

```

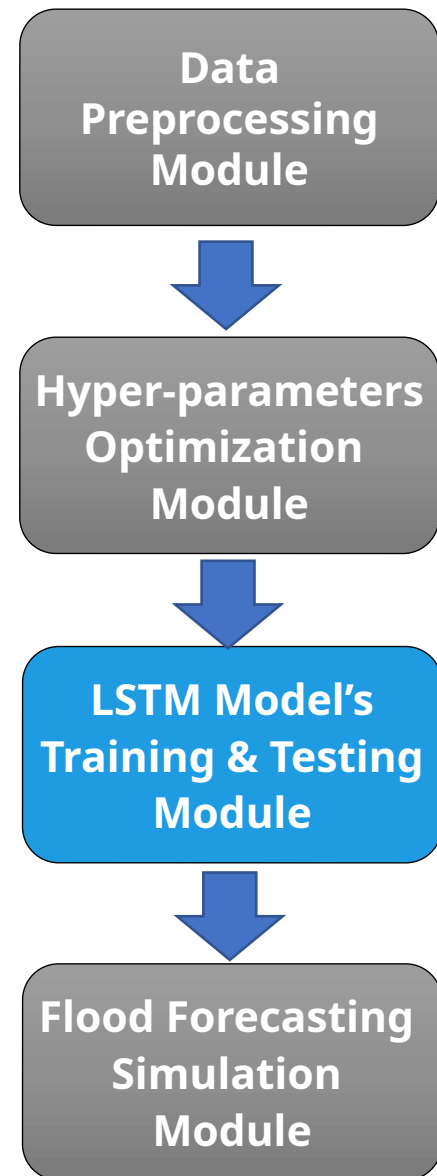
[BayesSearchCV] Best CV score: -0.166531
[BayesSearchCV] Best index: 16
[BayesSearchCV] Best params: {"batch_size": 32, "epochs": 34, "model__dropout": 0.43024544732394887, "model__lr": 0.01, "model__u": 10}
[BayesSearchCV] Best model type: Sequential
[BayesSearchCV] Best model summary:
Model: "sequential_101"
          
```

Layer (type)	Output Shape	Param #
lstm_101 (LSTM)	(None, 10)	840
dropout_101 (Dropout)	(None, 10)	0
dense_101 (Dense)	(None, 1)	11

Total params: 2,555 (9.98 KB)
Trainable params: 851 (3.32 KB)
Non-trainable params: 0 (0.00 B)
Optimizer params: 1,704 (6.66 KB)

AI Flood Forecasting

[Module3] LSTM Model's Training & Testing



2025-10-22 18:05:25

Flood Forecasting System Using AI

Data Preprocessing

1. Input Data Features
2. Correlation Analysis

Hyper-parameters Optimization (Bayesian Search)

1. Defining Searching Space and Optimized Parameters

LSTM Model's Training and Testing

1. Defining Hyper-parameters
2. Results

Flood Forecasting Simulation

1. Forecasting Input Data
2. Results

LSTM Model's Training and Testing / Defining Hyper-parameters / LSTM Model's Training and Testing / Results

1. Prediction Results in Training Period

Date	Observed	Predicted
2019-01-19 00:00	42.88	21.15
2019-01-20 00:00	42.88	21.15
2019-01-21 00:00	43.13	20.99
2019-01-22 00:00	43.62	20.8
2019-01-23 00:00	44.11	20.62
2019-01-24 00:00	44.85	20.44
2019-01-25 00:00	42.03	20.28

- Statistics

Performance Metrics	Value
MAE	12.778
NSE	0.368
R ²	0.372

2. Prediction Results in Testing Period

Date	Observed	Predicted
2020-12-23 00:00	31.61	19.53
2020-12-24 00:00	32.96	19.53
2020-12-25 00:00	32.84	19.53
2020-12-26 00:00	22.67	19.53
2020-12-27 00:00	20.09	19.53
2020-12-28 00:00	24.02	19.53
2020-12-29 00:00	35.17	19.53

- Statistics

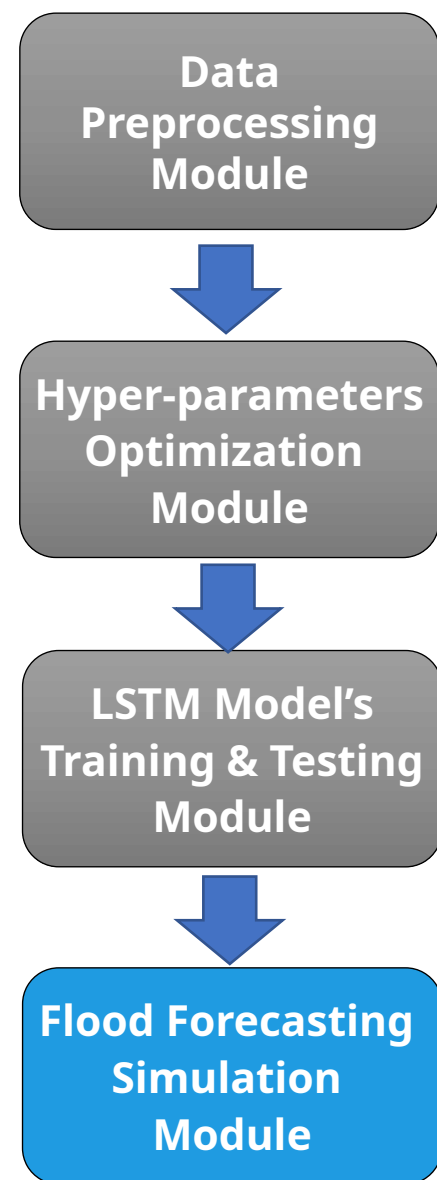
Performance Metrics	Value
RMSE	10.188
MAE	8.186
NSE	0.497
R ²	0.506


Prediction Results in Training Period Learning data: x2

Prediction Results in Testing Period Learning data: x1

AI Flood Forecasting


[Module4] Flood Forecasting Simulation





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Flood Forecasting System Using AI



Data Preprocessing

1. Input Data Features
2. Correlation Analysis

Hyper-parameters Optimization (Bayesian Search)

1. Defining Searching Space and Optimized Parameters

LSTM Model's Training and Testing

1. Defining Hyper-parameters
2. Results

Flood Forecasting Simulation

1. Forecasting Input Data
2. Results

Flood Forecasting Simulation / Forecasting Input Data / **Flood Forecasting Simulation / Results**

Date	Forecasted_Result
2019-08-23 00:00	4.89
2019-08-24 00:00	4.82
2019-08-25 00:00	4.64
2019-08-26 00:00	4.59
2019-08-27 00:00	4.42
2019-08-28 00:00	4.36
2019-08-29 00:00	4.16
2019-08-30 00:00	3.72
2019-08-31 00:00	3.34
2019-09-01 00:00	3.16
2019-09-02 00:00	3.47
2019-09-03 00:00	3.61
2019-09-04 00:00	3.67
2019-09-05 00:00	3.55
2019-09-06 00:00	3.59
2019-09-07 00:00	3.65
2019-09-08 00:00	3.48
2019-09-09 00:00	3.28
2019-09-10 00:00	3.08
2019-09-11 00:00	2.9

Forecasting AI Model Download

Learning data: Learning data: x1

Water Level (Predicted) and input forecast: start at t=13

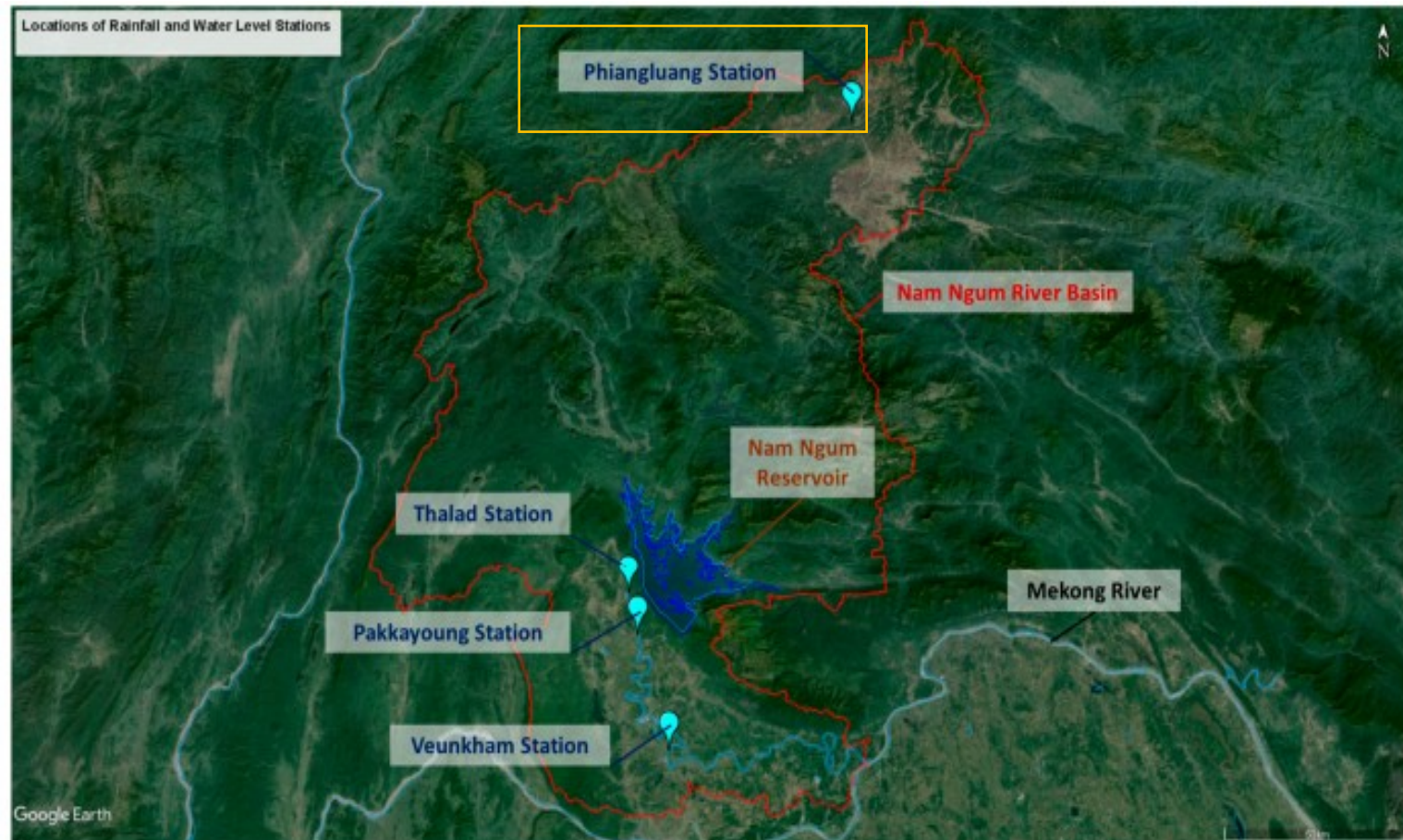
AI Flood Forecasting

Pilot Application: Lao. P.D.R

Data Period: Jan 2019 - Oct 2021 (About 3 years, 70% training, 30% testing)

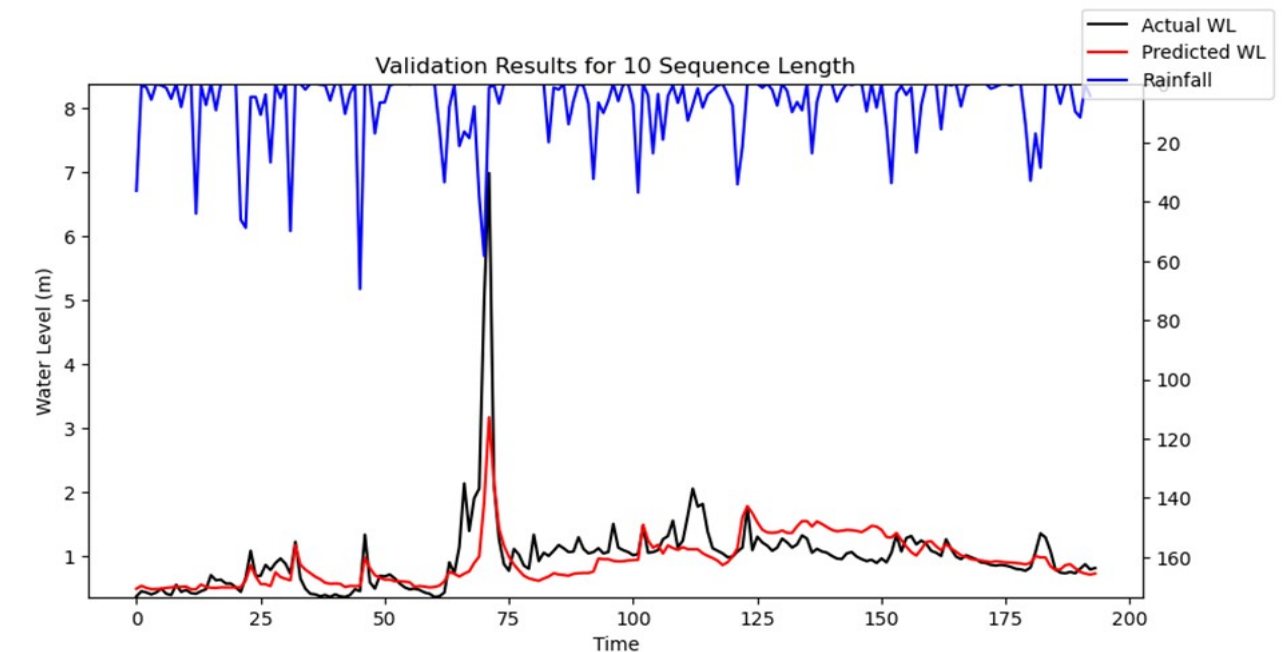
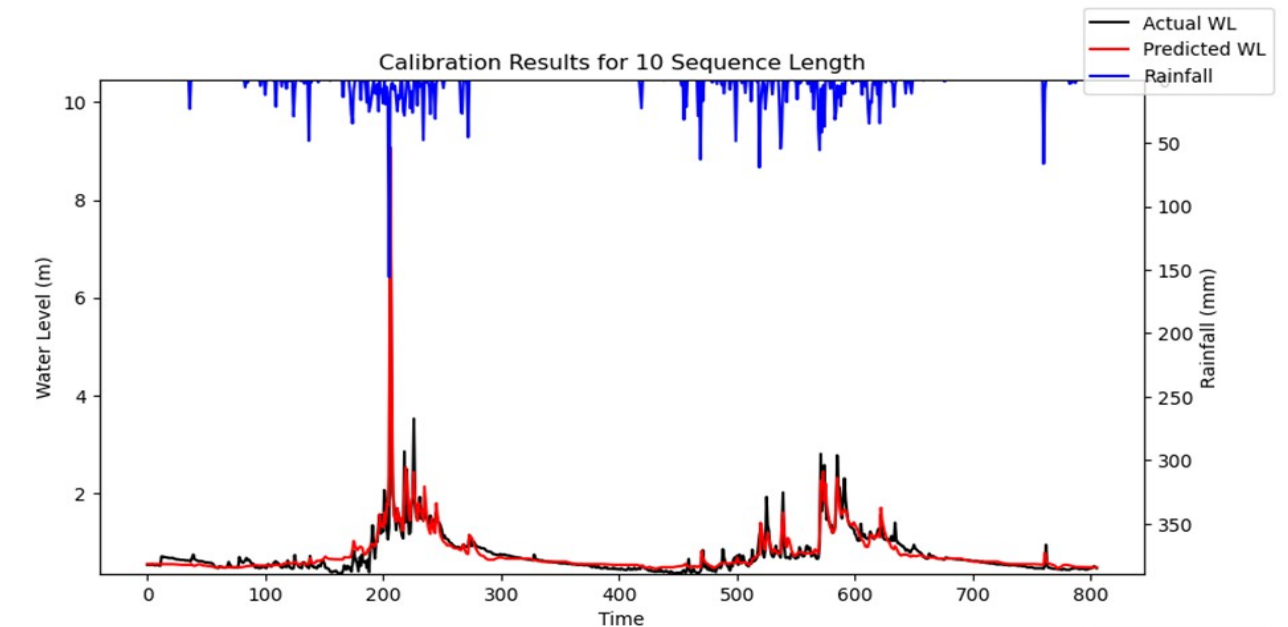
Input Data: Daily rainfall, 3-day, 5-day, 7-day cumulative rainfall, and monthly average water level at Phiangluang station

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

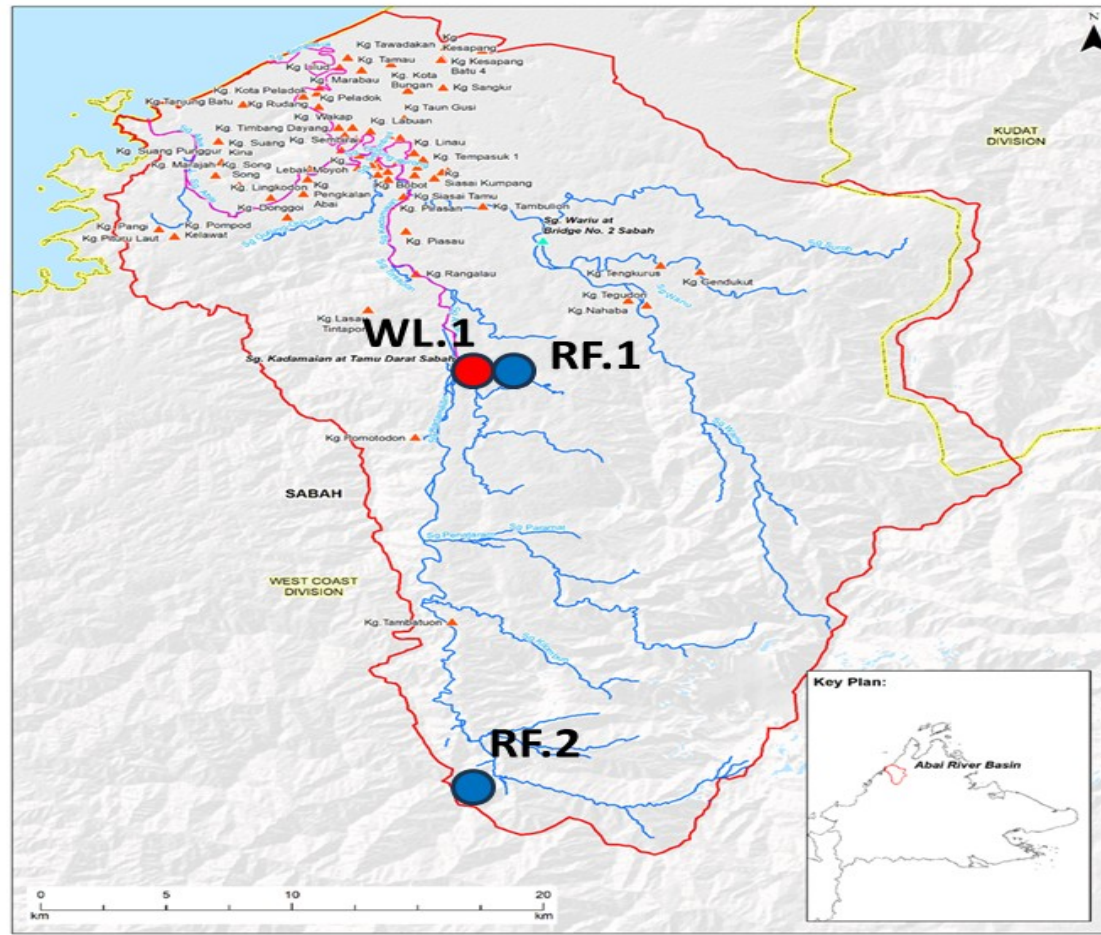


AI Flood Forecasting

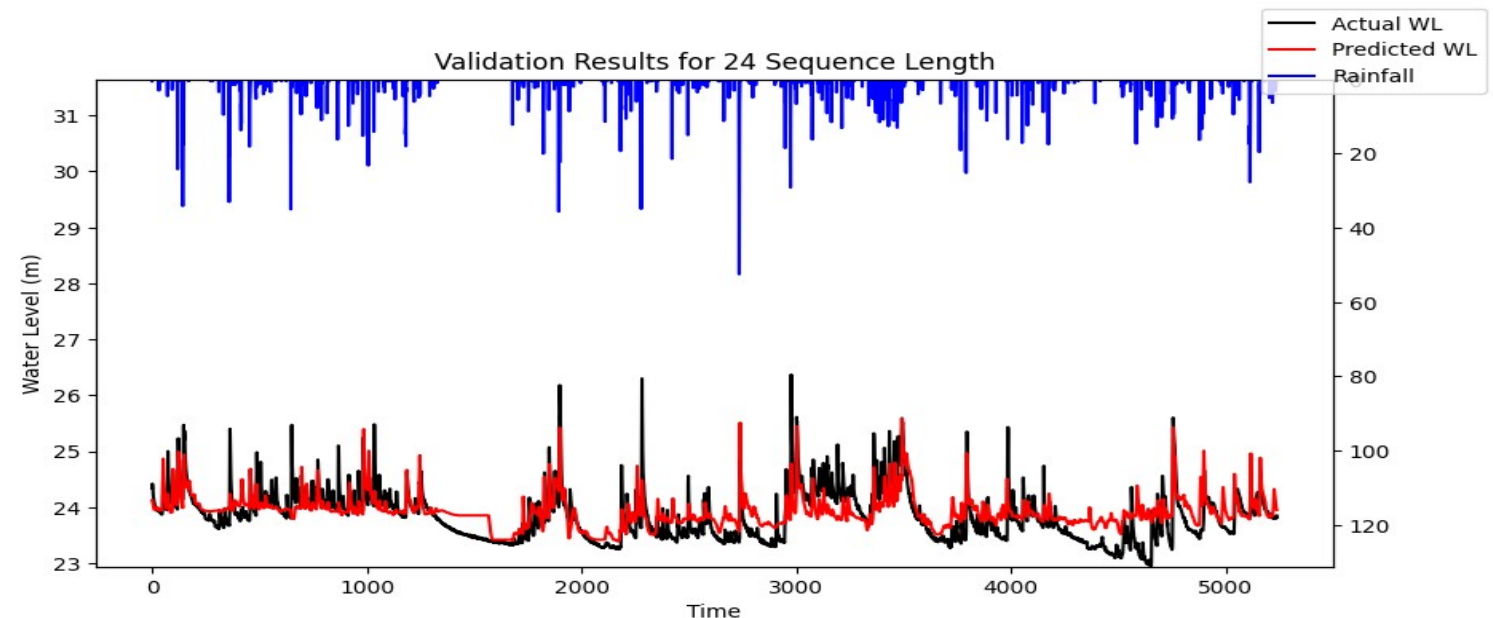
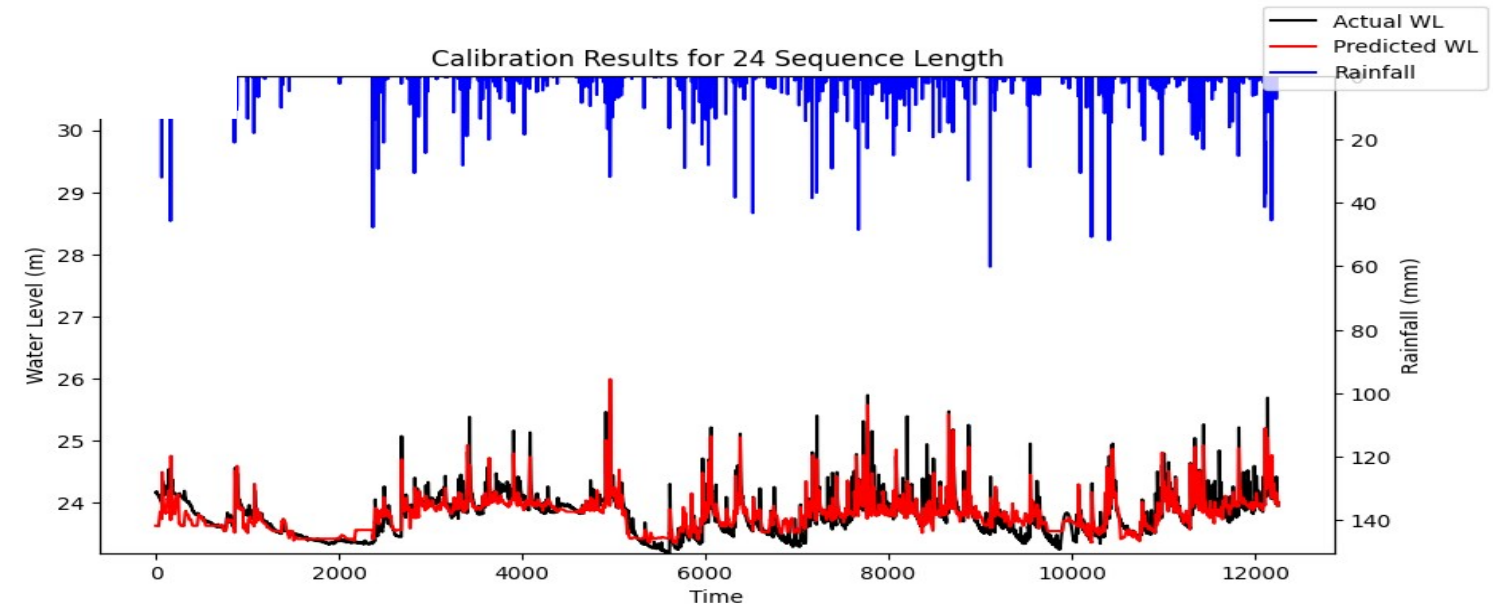
Pilot Application: Malaysia

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

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



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



“

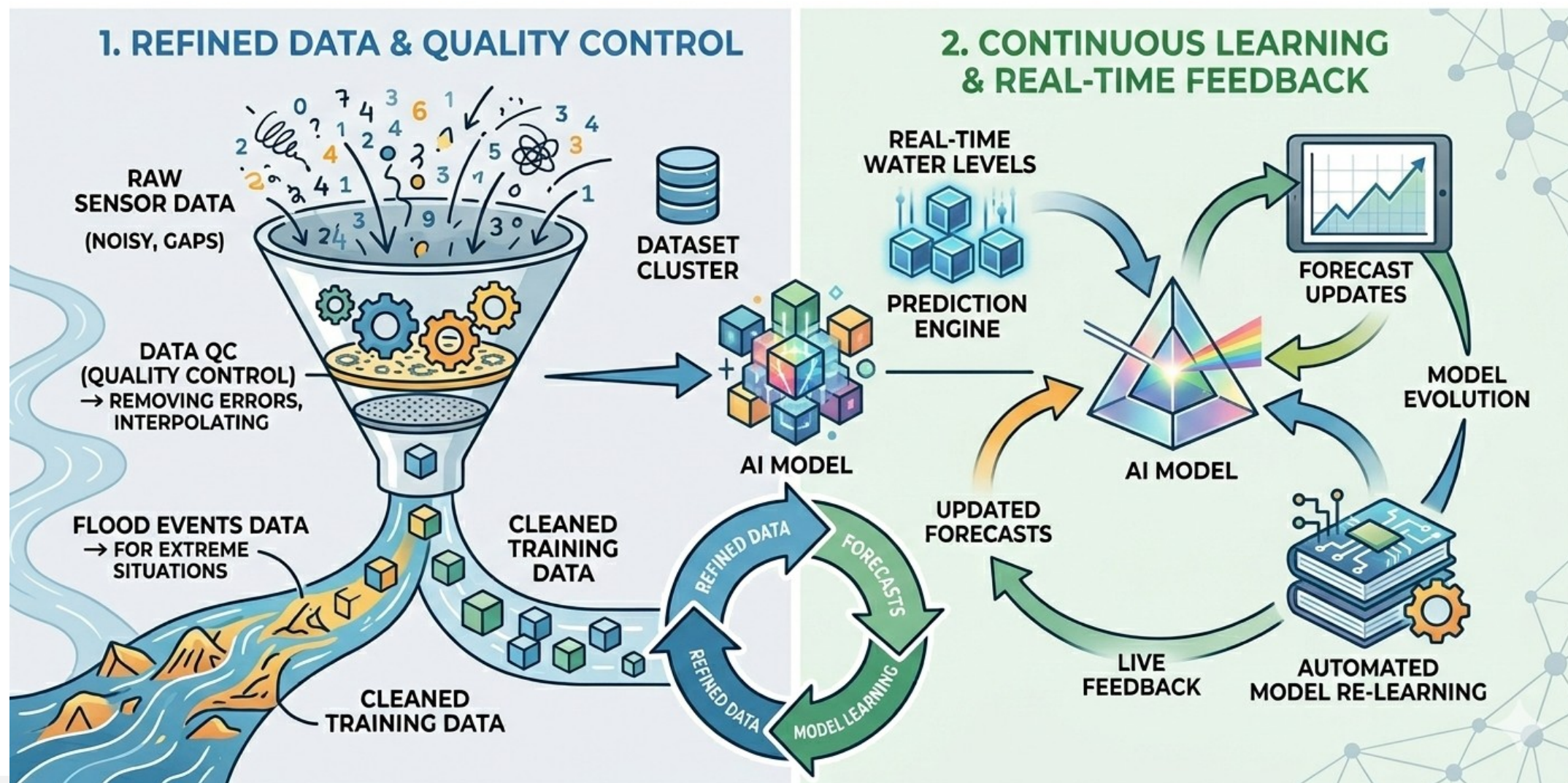
Conclusion

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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