A Realistic Method of Forecasting Dam Water Inflow for an Efficient Operation of Hydroelectric Power Stations including Pumped Storage

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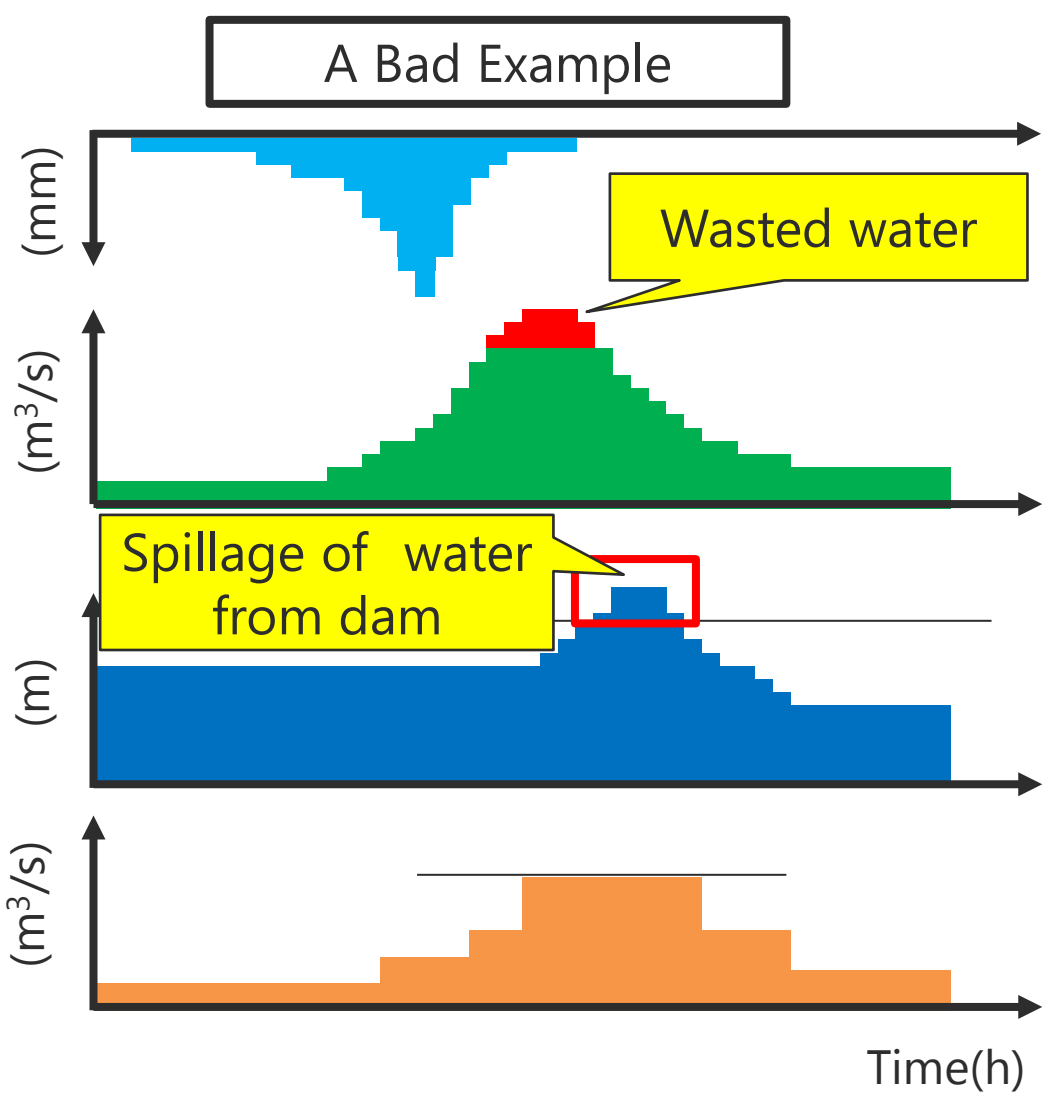
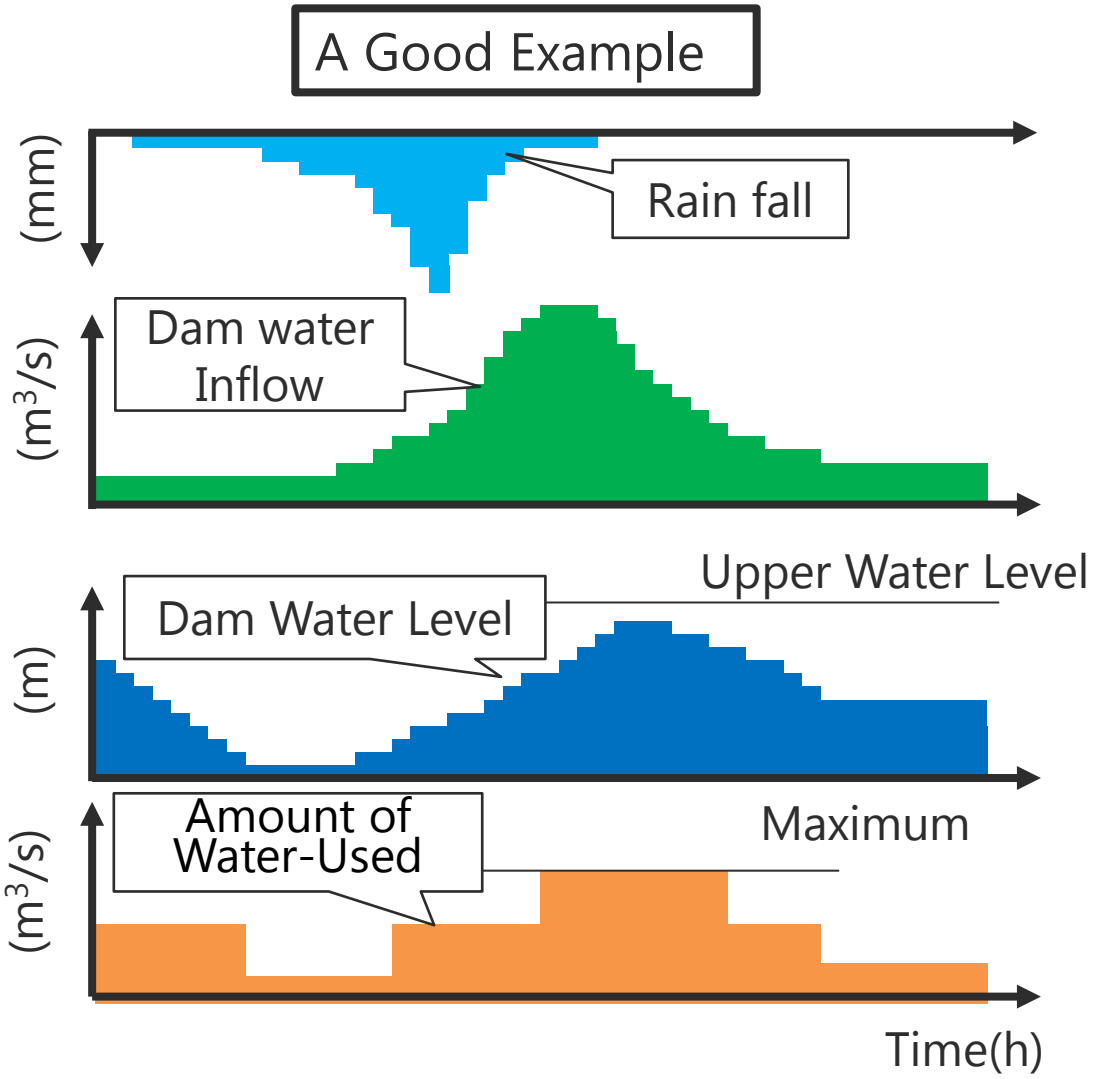
Main features of Japanese dams

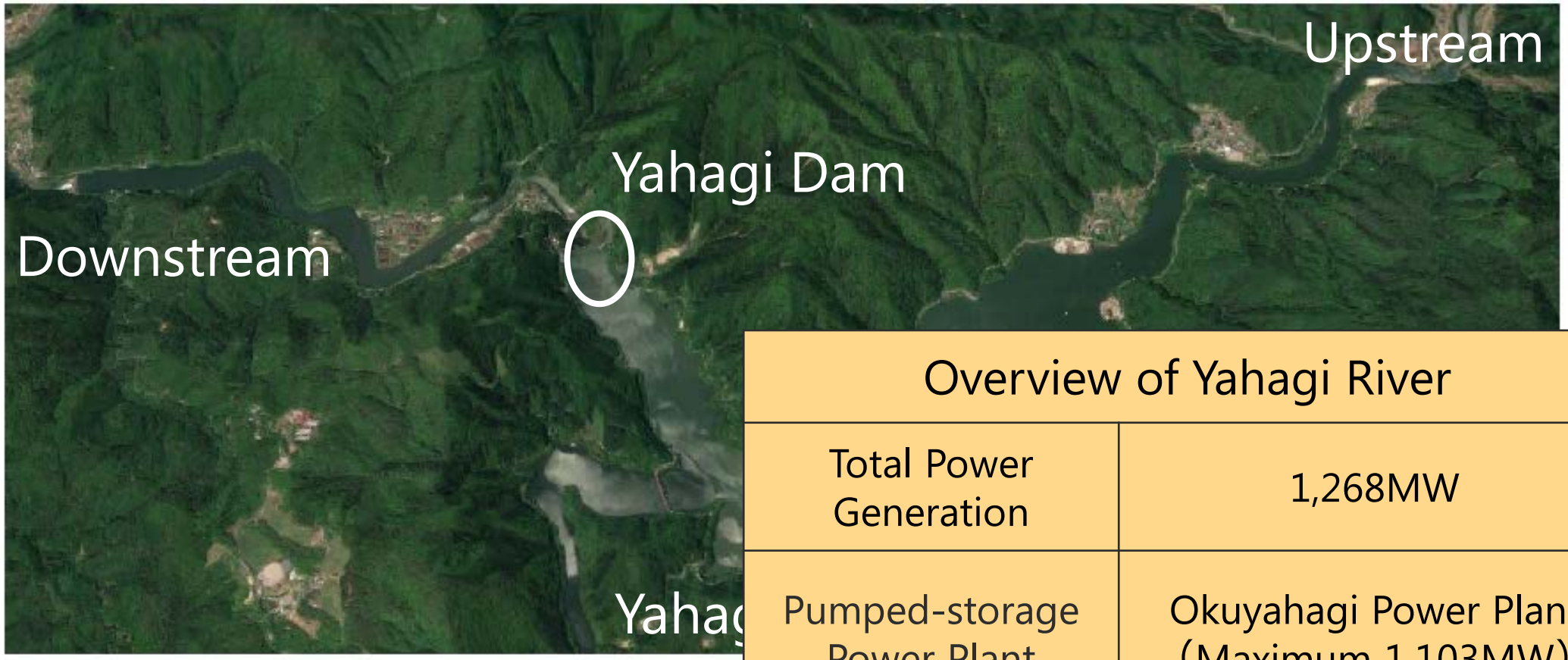
- Japan is a country rich in water resources, but the land that can be utilized as a dam for hydroelectric power stations are limited because the country is narrow.
- Compared to world-famous dams, the amount of water storage in Japanese dams is small.
- The dam water will spill if we do not operate the hydropower stations by forecasting the dam inflow at the time of rain.
- In order to make effective use of water resources, forecasting dam inflow at the time of rain is very important in Japan.

Importance of Forecasting Dam Water Inflow





An Example of Large River basin in Our Company



Overview of Yahagi River	
Total Power Generation	1,268MW
Pumped-storage Power Plant	Okuyahagi Power Plant (Maximum 1,103MW)
Catchment area	915 k m^2

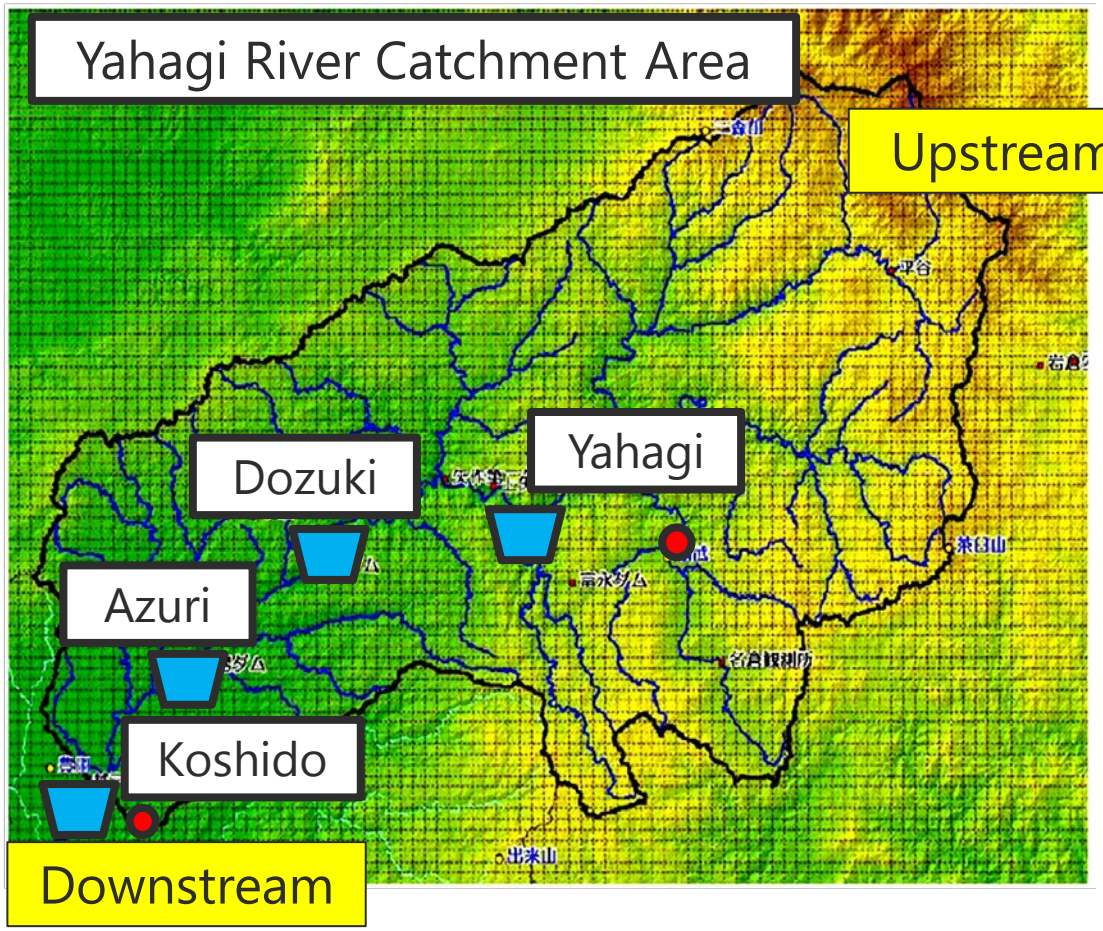
Present Method of Forecasting Dam Inflow

Present

Limited rain forecast points

⇩

Forecasting dam inflow
（By experience）



●：Rain forecast Point　▼：Major Dam

Present Problems and Operator's Needs

＜Problem＞

There are a few rain forecast points

➡ We can not respond to local heavy rain accurately

Forecasting dam water inflow by young operators are prone to relatively more error due to their limited experience

➡ We have problem of training young operators in a short time to gain experience

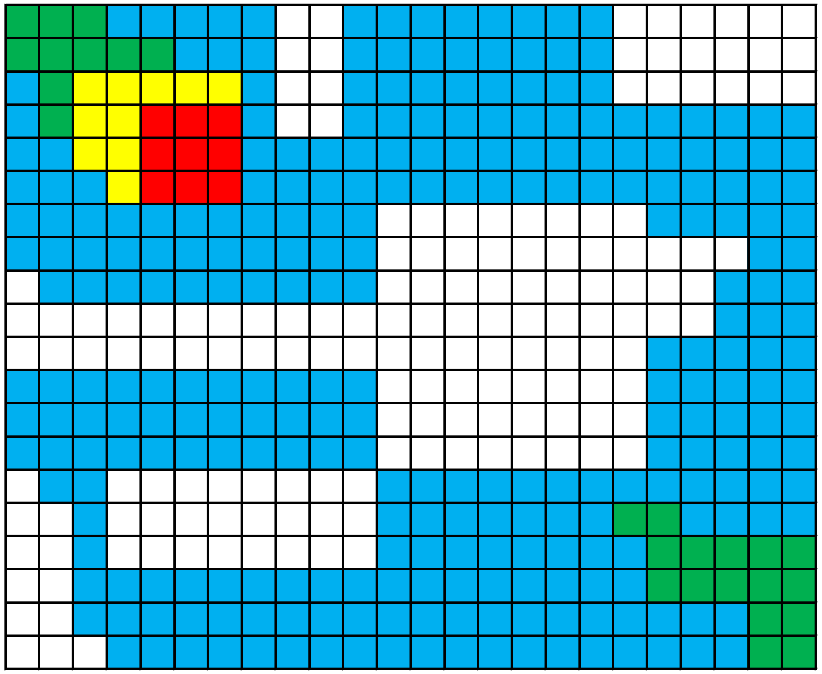
＜Operator’s Needs＞

・To improve lack of rain forecast points

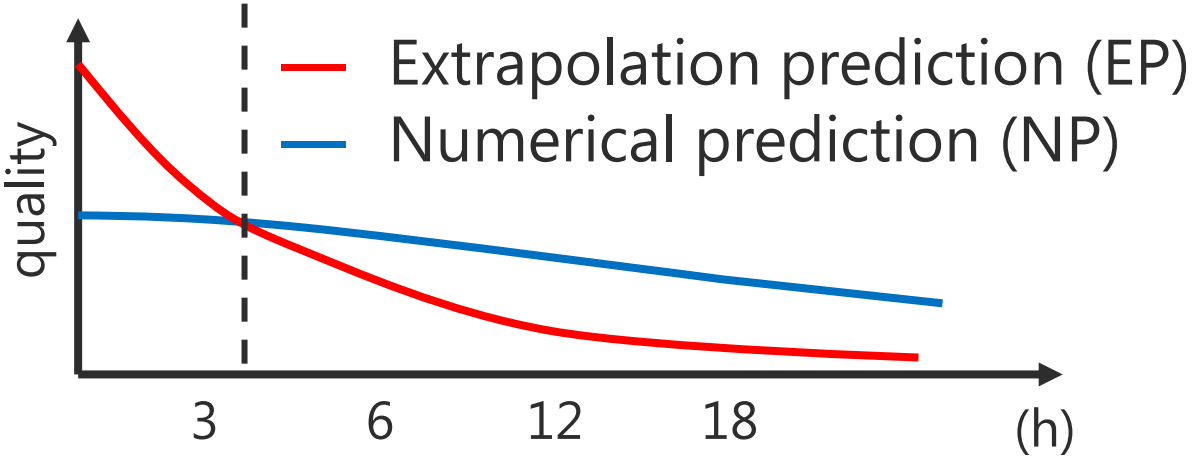
・To develop a realistic method of forecasting dam inflow irrespective of operator’s experience

To Improve Lack of Rain Forecast Points

Mesh Wise Rainfall Data



0～5mm
6-10mm
11-20mm
21-30mm



Forecast range：0～3 hours ahead
“**Very short range forecast**” (EP)
Rain forecast using JMA※1 and rain radar

Forecast range：3～51 hours ahead
“**SYNFOS－3D**” (NP)
Rain forecast using JWA※2 prediction model

※1 JMA: Japan Meteorological Agency
※2 JWA: Japan Weather Association

02 | A Realistic Method of Forecasting Dam Water Inflow（2）

CHUBU Electric Power

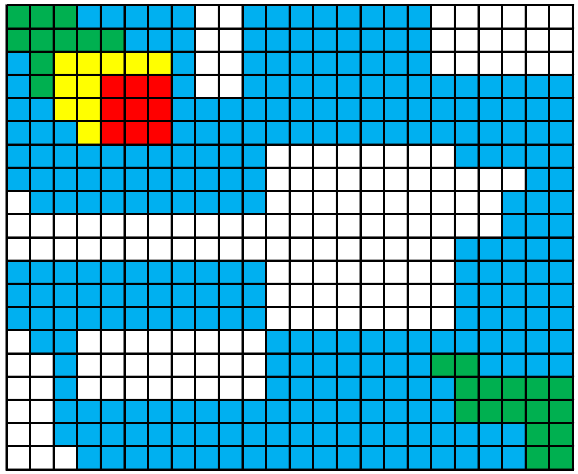
We have proposed a realistic method of forecasting dam water inflow using Mesh Type Run-off Model

Input

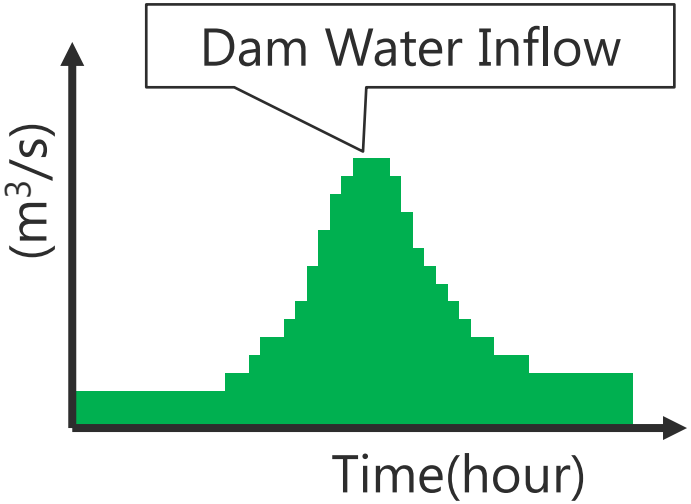
Method of Forecast

Output

Mesh Wise Rainfall Data



A Method of Forecasting Dam Water Inflow



Using

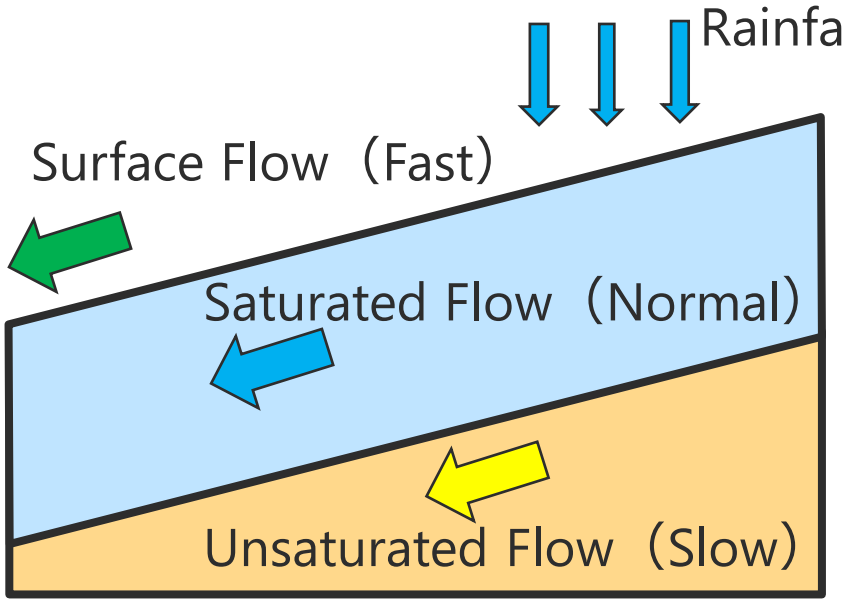
Mesh Type Run-off Model

Features of Mesh Type Run-off Model

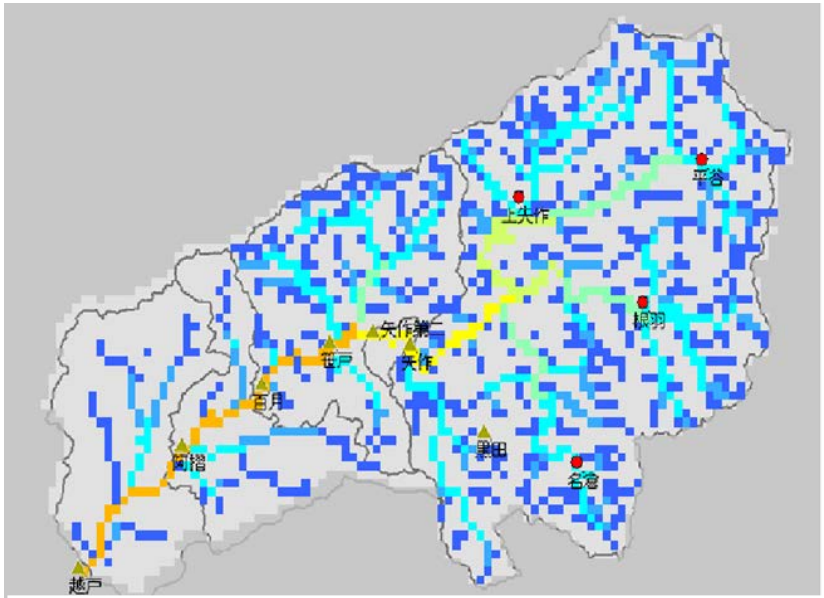
1．Rainfall data can be entered on mesh basis

2．It is possible to physically simulate the movement of water in terms of surface-flow (fast), saturated-flow (normal) and unsaturated-flow (slow) for each mesh unit

3．Forecast is possible at any point

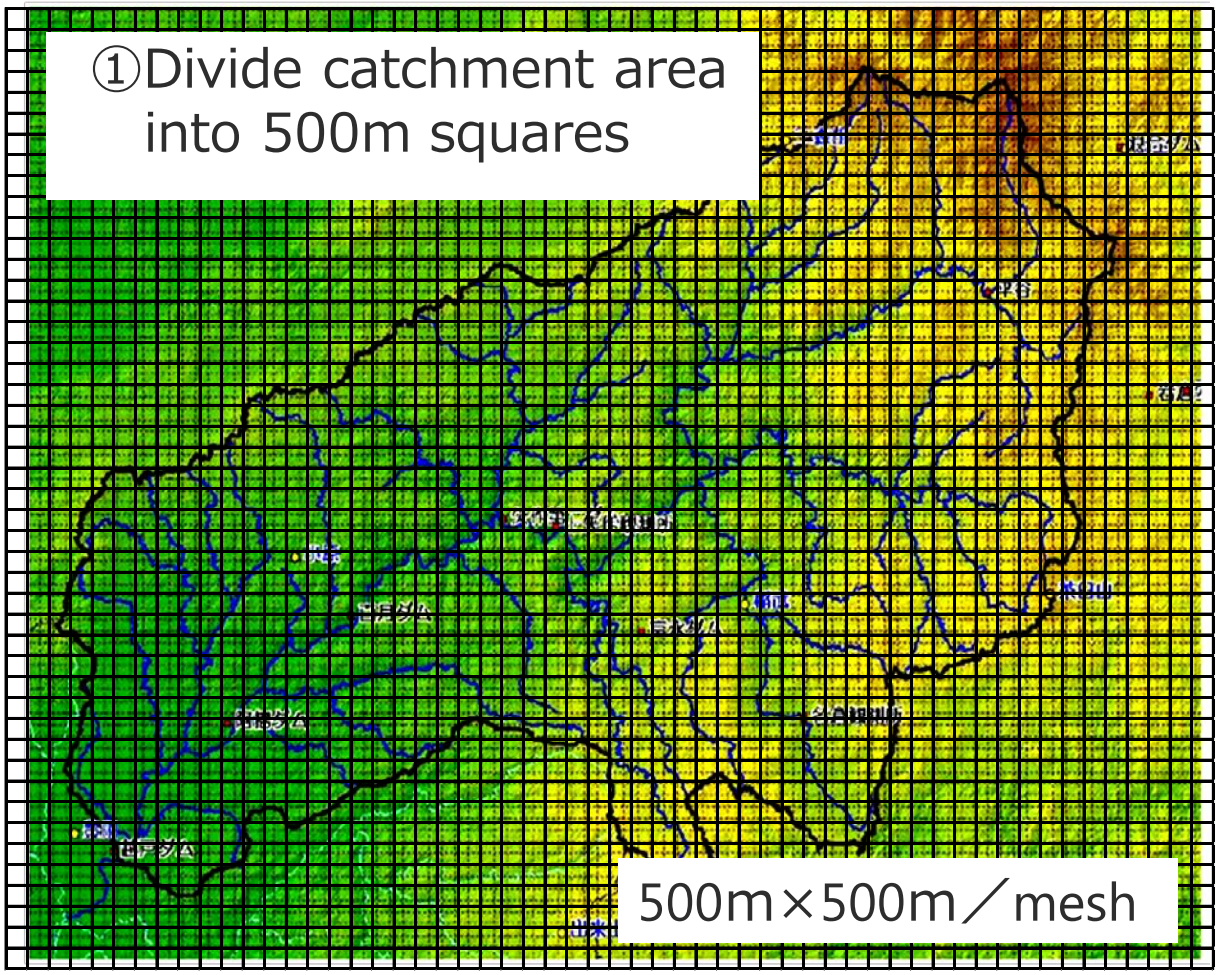


1. Image-illustration

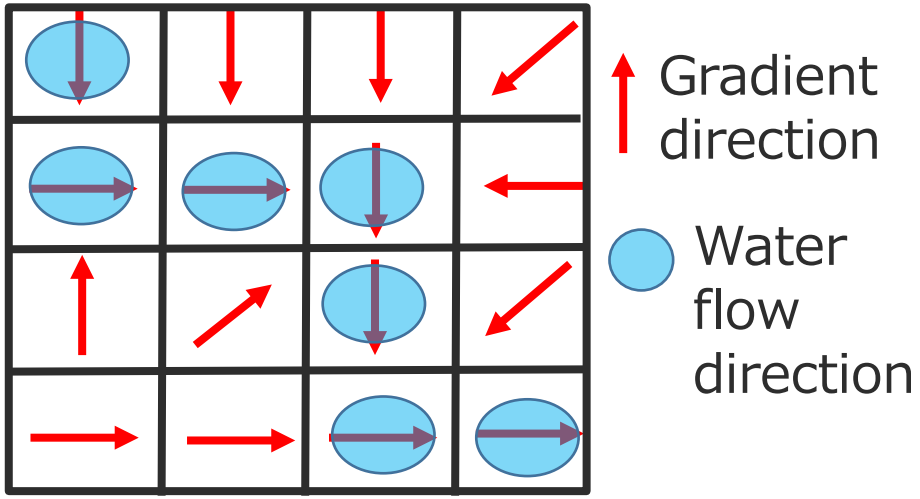


2. Image-illustration

Details of Mesh Type Run-off Model（1）

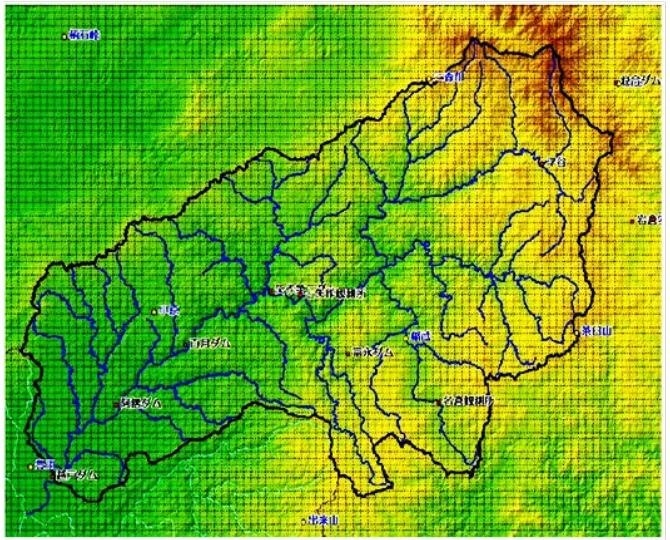


②Determine gradient direction for each mesh and identify water flow direction



③Determine parameters for each mesh（Next page）

Details of Mesh Type Run-off Model （2）



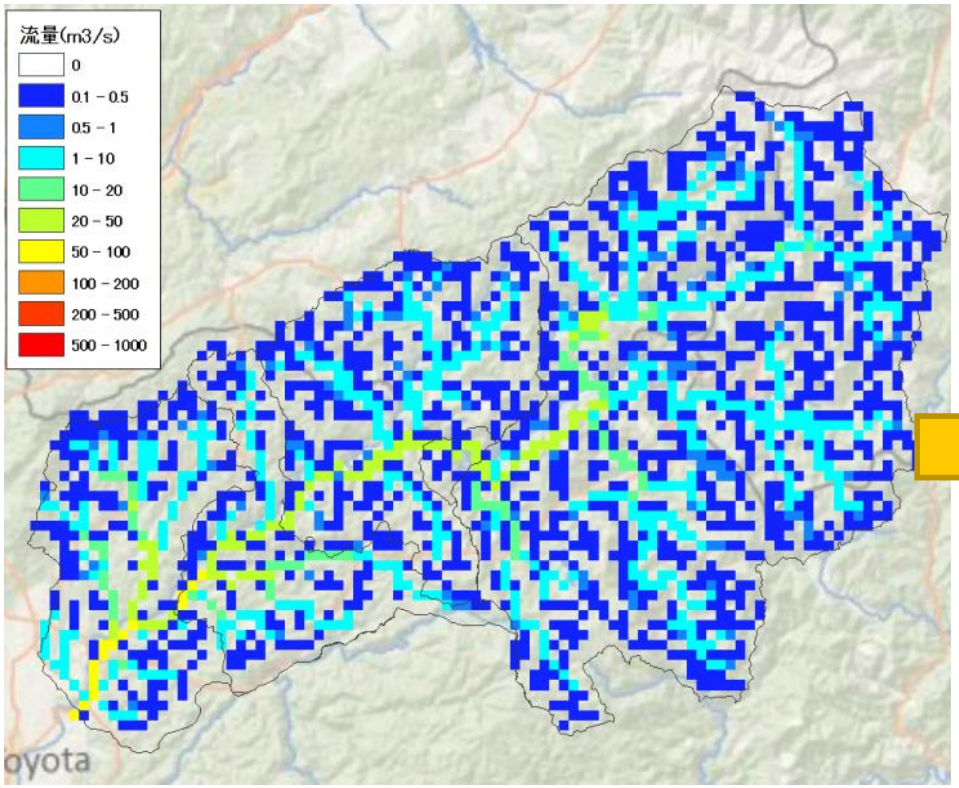
①Determine type of soil for each mesh

②Determine parameters for each type of soil

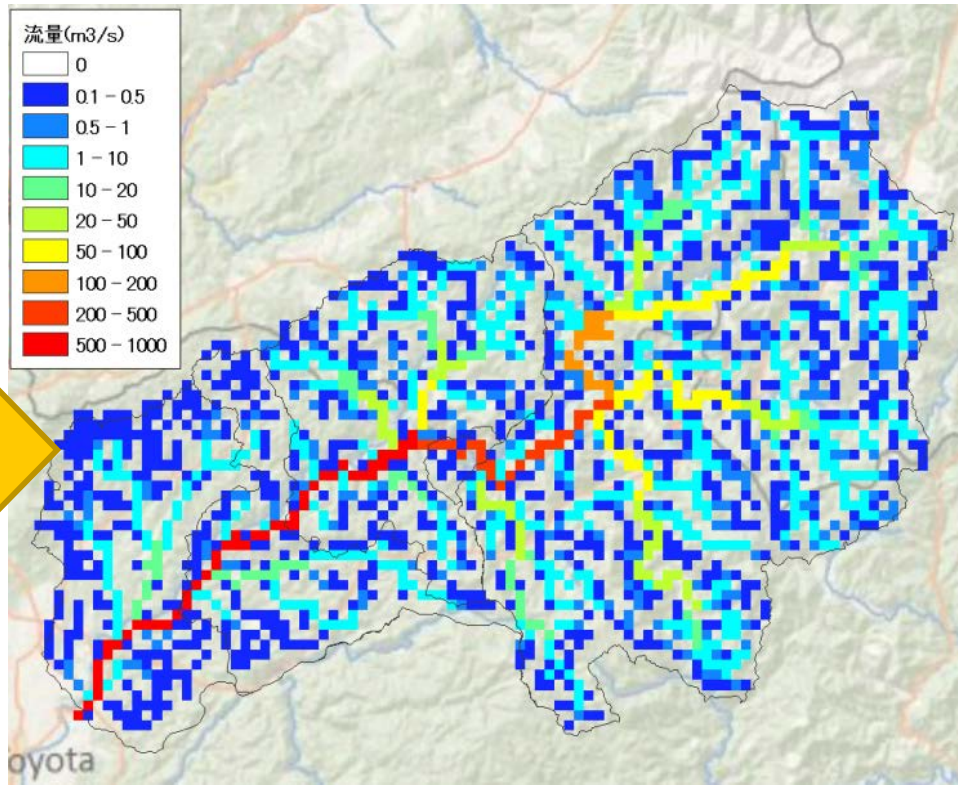
Parameters（3/Max:8）	Type of Soil							
	Paddy field	Field	Orchard	Forest	Waste land	Resi -dence	Water area	River
Easiness of Water Penetration	0.005	0.005	0.005	0.010	0.005	0.005	0.005	-
Soil Depth	300	300	300	400	300	200	300	0
Easiness of Water Flow	1.0	1.0	2.0	2.6	2.0	0.3	2.0	0.007

Water flow changes with time（Image）

After 1 Hour



After 3 Hours



Parameters Adjustment（1）

1．Collected actual data of “rainfall” and “dam water inflow” from 2012-2015. then extracted 30 cases out of them.

2．Enter rainfall data (observed values) into the forecasting model. then compare “calculated values” to “observed values”.

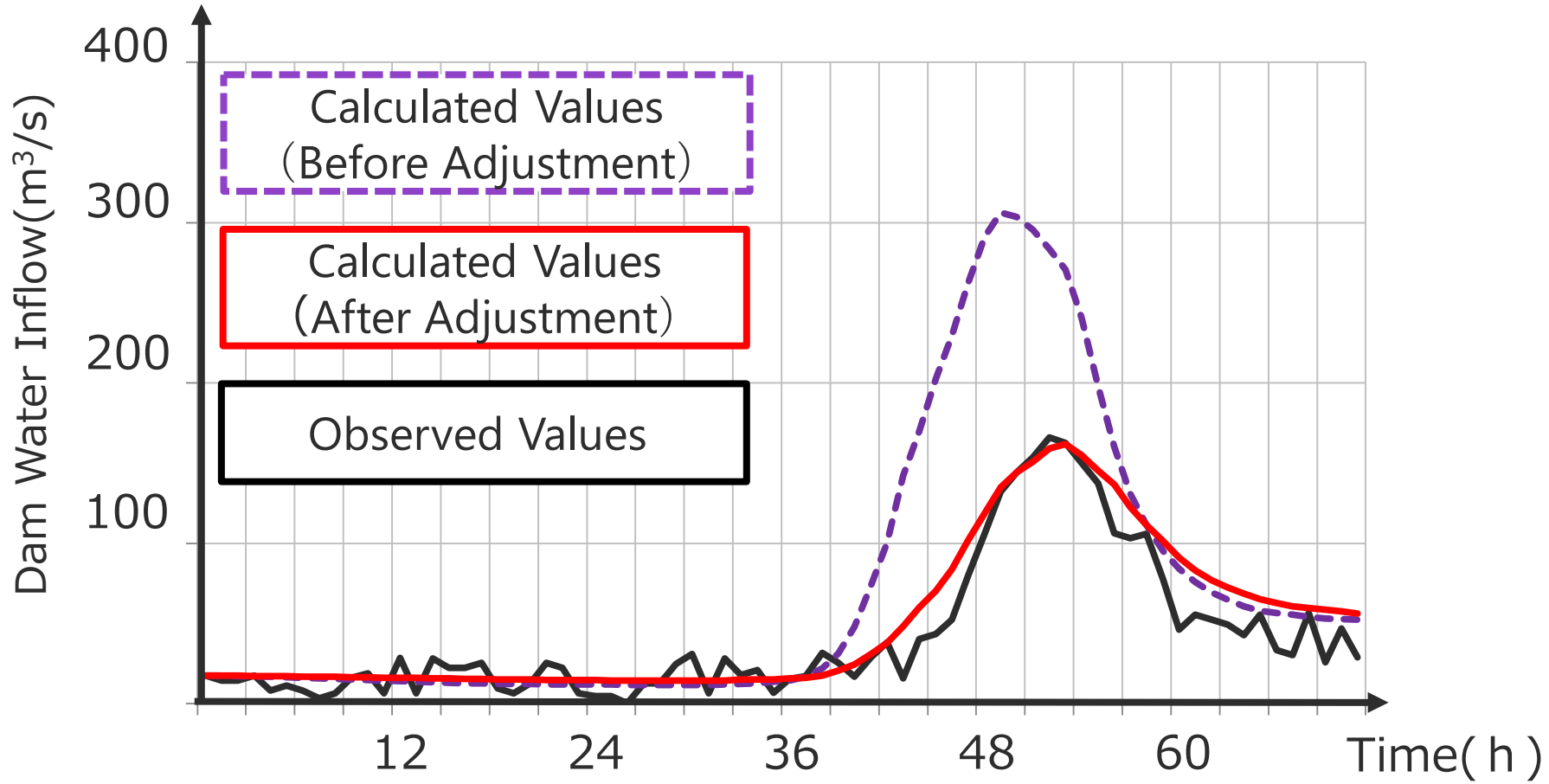
3．To make all case errors smaller with one combination of parameters, the adjustment of the parameters was carried out repeatedly.

Parameters Adjustment（2）

Parameters	Type of Soil			Parameters	Type of Soil		
	Paddy field	Field	Orchard		Paddy field	Field	Orchard
Easiness of Water Penetration	0.005	0.005	0.005	Easiness of Water Penetration	0.005	0.005	0.005
Soil Depth	300	300	300	Soil Depth	↑ 300	↑ 300	↑ 300
Easiness of Water Flow	↑ 1.0	↑ 1.0	↑ 2.0	Easiness of Water Flow	1.0	1.0	2.0

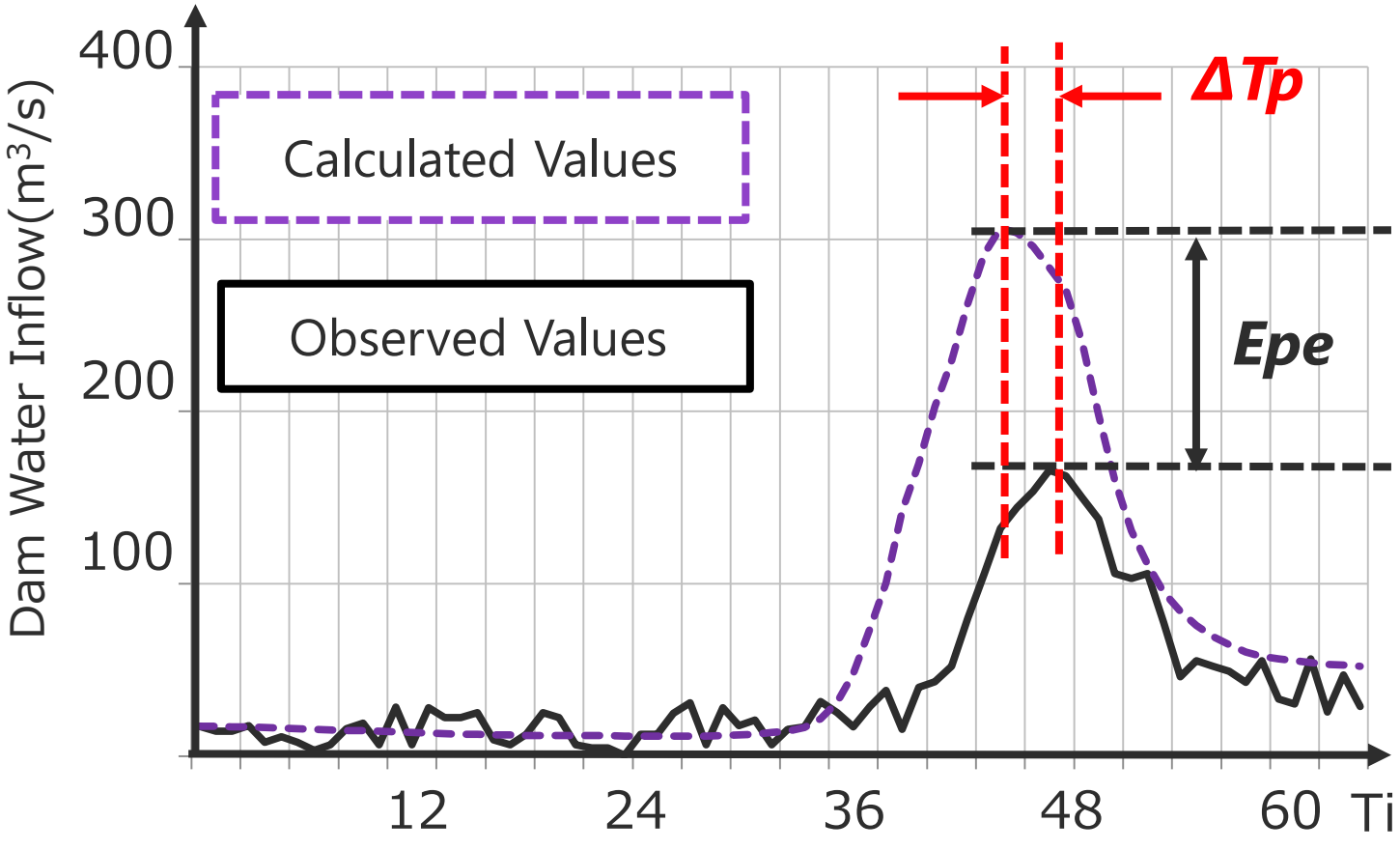
Parameters Adjustment（3）

Comparison of forecast results before and after parameter adjustment



Evaluation method for Forecast accuracy

Error of Peak Value (*Epe*)	Error of Peak Time (*ΔTp*)	Error of Total Amount (*Eta*)



$$E_{ta} = \frac{\sum_{i=1}^{N} q_{ci} - \sum_{i=1}^{N} q_{oi}}{\sum_{i=1}^{N} q_{oi}}$$

q_{ci}: Calculated Value
q_{oi}: Observed Value

The Target value for Forecast Error

The Target value for Forecast Error
（Based on interview with the operators）

Error of Peak Value (*Epe*)	Error of Peak Time (ΔTp)	Error of Total Amount (*Eta*)
30.0%	0 ～ early 1 hour	30.0%

Forecast Error Results （After adjusting the parameters)

Number of Cases	Error of Peak Value (*Epe*)	Error of Peak Time (ΔTp)	Error of Total Amount (*Eta*)
30	Average 25.7%	Average 1.0h	Average 30.2%

The results are found to be satisfactory to meet the needs of the operator

04 Conclusion

- ✓ We have developed a dam water inflow forecasting method using mesh type run-off model.
- ✓ The proposed method was verified by actually manufacturing the prototype system and testing it on the Yahagi river basin.
- ✓ On adjusting the model parameters appropriately during testing, the forecast results were found to be quite satisfactory to meet the needs of the operator.
- ✓ In future, on applying the developed forecast method to the actual river basins, it is possible to realize more efficient operation of power stations by reducing the water spillage, more flexibility of pumped storage station due to less restriction.

Thank you for your kind attention

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