Estimation of the probable maximum precipitation (PMP) return period in the NPP site

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1. Introduction

When designing domestic nuclear power plants, a flood assessment is conducted at the site using probable maximum precipitation (PMP). The PMP return period is a concern because of recent climate change and increased extreme precipitation. Therefore, in this study, we estimate the return period of PMP used in the field.

The PMP applied domestically estimates rainfall by reading it from the PMP map. This method makes it difficult to estimate the return period. Therefore, the probability of precipitation should be estimated through regional frequency analysis (RFA) and at-site frequency analysis (AFA) and compared with the PMP to determine the return period.

2. Methods and Results

This study applied two methods to estimate the return period of PMP. First, the return period for PMP was estimated using RFA. Secondly, the PMP return period was estimated by calculating the probabilistic precipitation for each type of distribution using AFA. Recent observational data up to 2022 were used to estimate probabilistic precipitation. Also, probabilistic precipitation estimation was conducted using our proprietary precipitation estimation code.

2.1 PMP

The cases of PMP applied in specific domestic nuclear power plants are as follows.

Table 1. PMP

PMP (mm)					
Area (Km^2)	1 hr	2 hr	6 hr	12 hr	24 hr
2.5	205.3	266.0	534.6	775.5	1190.2

2.2 Probabilistic precipitation by RFA

RFA uses data from all precipitation points with similar precipitation patterns in a particular area. This method estimates precipitation in regions where actual data is unavailable. To this end, this study estimated the probabilistic precipitation at the target nuclear power plant by applying the methodology according to Standard guidelines for flood estimation (2019) [1].

Table 2. Estimation of Probabilistic precipitation by RFA

[Unit: mm]

Return period (y)	1 hr	2 hr	6 hr	12 hr	24 hr
10	57.3	86.7	151.2	199.1	247.0
20	66.0	101.7	179.5	237.4	293.6
30	71.1	110.8	196.9	261.0	322.1
50	77.5	122.5	219.8	292.3	359.4
70	81.8	130.5	235.6	314.0	385.1
80	83.5	133.7	242.0	322.9	395.5
100	86.4	139.1	253.0	338.0	413.2
200	95.5	156.6	288.9	387.6	470.8
300	100.7	167.2	311.2	418.7	506.5
500	107.5	181.0	340.8	460.2	553.7
10000	149.5	274.2	554.5	765.1	887.8
15000	155.5	288.5	589.6	815.9	941.7
100000	184.4	361.8	777.2	1091.6	1227.0
200000	195.4	391.4	856.7	1210.0	1346.4
300000	201.9	409.4	906.2	1284.2	1420.4
350000	204.4	416.4	925.7	1313.5	1449.4
400000	206.6	422.5	942.8	1339.2	1474.9

2.3 Probabilistic precipitation by AFA

AFA is a method of estimating the probabilistic precipitation using data from rainfall observation stations near the target area. This study applied AFA to estimate the probabilistic precipitation according to GEV, GUM, GLO, and GNO distributions.

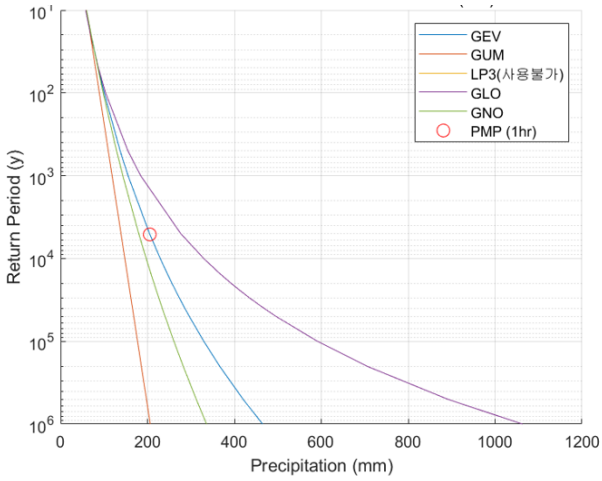

Fig. 1. Estimation of probabilistic precipitation by AFA (1 hr)

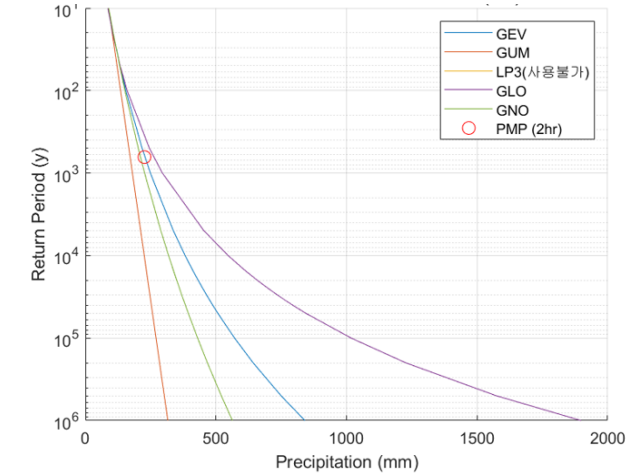

Fig. 2. Estimation of probabilistic precipitation by AFA (2 hr)

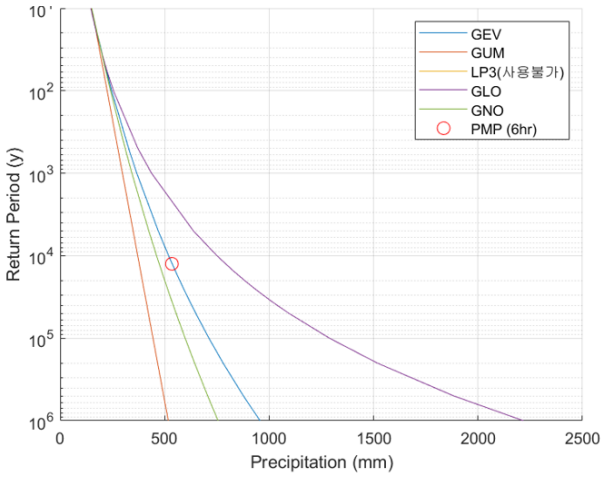

Fig. 3. Estimation of probabilistic precipitation by AFA (6 hr)

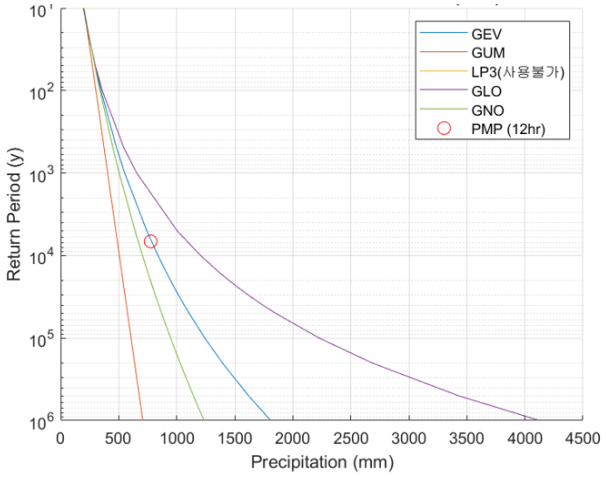

Fig. 4. Estimation of probabilistic precipitation by AFA (12 hr)

2.4 Estimation of the PMP return period

Lastly, the return period was estimated by comparing the estimated probabilistic precipitation from RFA and AFA with the PMP.

Table 3. Estimation of PMP return period by RFA

Duration	1 hr	2 hr	6 hr	12 hr	24 hr
PMP (mm)	205.3	266.0	534.6	775.5	1190.2
Return period (y)	About 396,000	About 9,200	About 8,900	About 15,000	About 86,000

Table 4. Estimation of PMP return period by AFA (1 hr)

Distribution	GEV	GUM	GLO	GNO
PMP (mm)	205.3			
Return period (y)	About 5,100	About 1 million	About 1,400	About 14,000

Table 5. Estimation of PMP return period by AFA (2 hr)

Distribution	GEV	GUM	GLO	GNO
PMP (mm)	266.0			
Return period (y)	About 1,782	About 80,000	About 710	About 3,523

Table 6. Estimation of PMP return period by AFA (6 hr)

Distribution	GEV	GUM	GLO	GNO
PMP (mm)	534.6			
Return period (y)	About 12,540	About 1.7 million	About 2,944	About 35,788

Table 7. Estimation of PMP return period by AFA (12 hr)

Distribution	GEV	GUM	GLO	GNO
PMP (mm)	775.5			
Return period (y)	About 6,733	About 4.7 million	About 2,382	About 20,480

3. Conclusions

This study estimated the return period of PMP applied in the field using the probabilistic precipitation. However, comparing the PMP's return period with the probabilistic precipitation frequency isn't accurate. Therefore, it is necessary to utilize a statistical method, one of the PMP estimation techniques, and compare it to the probabilistic precipitation return period.

Acknowledgments

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