Probable Maximum Precipitation Using the Revised K_m-Value Method in Hong Kong

This presentation participates in OSPP
EGU
Outstanding Student Poster & PICO Contest

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Introduction

Hershfield's K_m-value method is the most well-known statistical method for Probable Maximum Precipitation (PMP) estimation. However, there is a controversy between K_m and Φ_m in China which one should be used in the PMP estimation equation. In this study, we proved the relationship between K_m and Φ_m. Therefore, K_m could be used to estimate PMP under some conditions. This revised K_m-valued method was used in the estimation of 24-hr PMP in Hong Kong.

The revised K_m-value method

$$K_m = \frac{X_m - \bar{X}_{n-1}}{S_{n-1}}$$

$$\Phi_m = \frac{X_m - \bar{X}_n}{S_n}$$

$$\bar{X}_n = \frac{(n-1)\bar{X}_{n-1} + X_m}{n}$$

$$S_n^2 = \frac{1}{n-1}\sum_{i=1}^{n}(X_i - \bar{X}_n)^2$$

$$\Phi_m^2 = \frac{(n-1)^3}{n^2(n-2)}K_m^2 - \frac{n-1}{n(n-2)}K_m^2\Phi_m^2$$

where X_m is the highest value of the series $(X_1, X_2, \cdots, X_n)$, $\bar{X}_{n-1}$ and S_{n-1} are, respectively, the mean and the standard deviation excluding the highest value from the series. $\bar{X}_n$ and S_n are, respectively, the mean and the standard deviation of the series.

Making $C_1 = \frac{(n-1)^3}{n^2(n-2)}$, $C_2 = \frac{n-1}{n(n-2)}$, the following equations could be got,

$$K_m = \Phi_m\sqrt{\frac{1}{C_1 - C_2\Phi_m^2}} \quad (1)$$

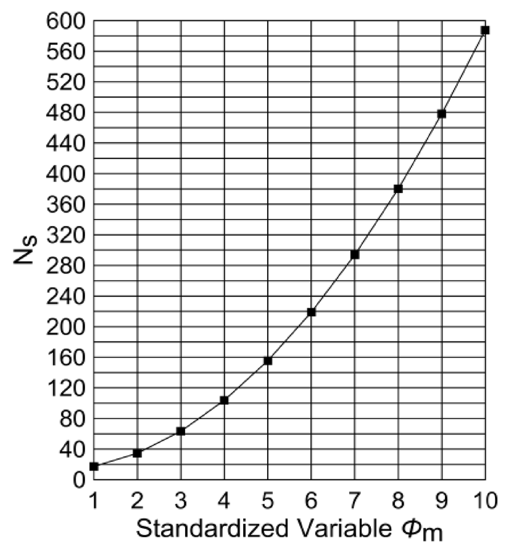
The Conditions

(1) The minimum data size, N_m

$$N_m = \Phi_m^2 + 2$$

(2) The stable data size, N_s

$$5.76(\Phi_m^2 + 2) \le N_s \le 3.5n$$



Relationship of variation coefficient Φ_m with N_s

The sample error adjustment

$$\bar{X}_n' = (1 + 3C_{vn}/\sqrt{n})\bar{X}_n$$

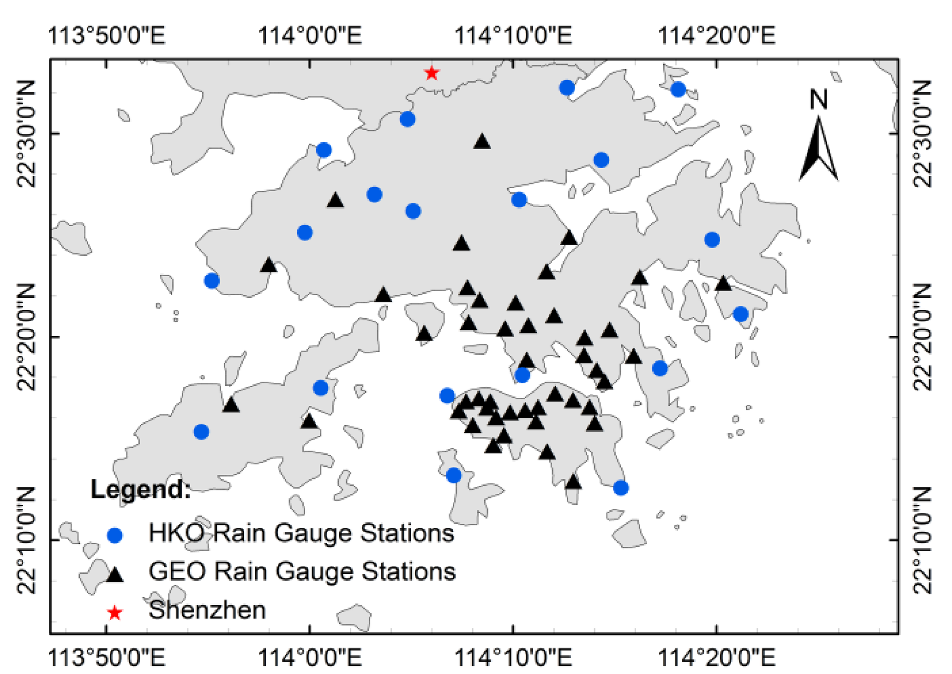
Where $\bar{X}_n'$ is the adjustment sample mean, C_{vn} is the deviation coefficient. Furthermore, if the rainfall data are observed at fixed time, it should be multiplied by a conversion factor of 1.13.

The equation of PMP estimation

By enveloping K_m from a large number of computed K_m, PMP could be estimated by the following equation:

$$X_{PMP} = \bar{X}_n + K_m S_n \quad (2)$$

Case study—Data



Locations of 64 rain-gauge stations in Hong Kong and Shenzhen

a. 63 rain-gauge stations in Hong Kong: 5-min data
b. Hong Kong Observatory : Hourly data
c. Shenzhen: annual maximum 24-hr rainfall

Results

Table The calculations of the revised K_m-value method applied in Hong Kong and Shenzhen

No.	Stations	Years	X_m	C_{vn}	$\bar{X}_n'$	K_m	Φ_m	N_m	$N_s \ge 5.76(\Phi_m^2 + 2)$	$N_s \le 3.5n$
1	N14	27	956.0	0.53	**426.30**	**5.46**	3.66	16	89	94
2	N09	27	800.0	0.52	334.41	7.20	4.09	19	108	94
3	N17	20	745.0	0.53	389.95	4.32	2.99	11	64	70
4	R11	24	735.5	**0.57**	365.11	4.01	3.01	12	64	84
5	HKO	119	697.1	0.42	233.36	5.26	4.71	25	261	416
6	N02	27	587.5	0.42	313.82	4.19	3.18	13	70	94
7	N01	27	570.0	0.41	331.02	3.38	2.77	10	56	94
8	N15	27	562.0	0.37	284.04	5.82	3.76	17	94	94
9	K02	27	508.0	0.41	319.38	2.72	2.36	8	44	94
10	N06	27	508.0	0.39	320.70	2.78	2.40	8	45	94
…	…	…	…	…	…	…	…	…	…	…
65	R13	24	284.5	0.31	217.60	1.97	1.79	6	30	84

$$X_{PMP} = (1 + K_m C_{vn})\bar{X}_n = (1 + 5.46 * 0.57) * 426.30 \approx 1753\ (mm)$$

Discussions and conclusions

- ➢ It proved that K_m had an obvious statistical relationship with Φ_m. So K_m is utilized in PMP estimation with maximization effect under some conditions to reduce computation error.
- ➢ The longer data series is better for the method. However there are few stations in the world that are long enough to get reliable PMP estimates. So it must be taken caution when using the method.
- ➢ The statistical result is still a point PMP, and is only considered to be a reference value.
- ➢ Storm transposition and DAD method would be applied to estimate 24-hr PMP in Hong Kong to get the comparable results in future.

Acknowledgments

Thanks to the Civil Engineering and Development of the Hong Kong Special Administrative Region (HKSAR) and Hong Kong Observatory (HKO).

https://doi.org/10.1061/(ASCE)HE.1943-5584.0001517#sthash.PSrUbYhy.dpuf EGU 2017-19329