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

P. Lan$^{1,*}$, B. Lin$^{2,3}$, Y. Zhang$^{2,3}$, H. Chen$^4$

$^1$College of Atmospheric Science, Nanjing University of Information Science & Technology, Nanjing, 210044, China
$^2$College of Hydrometeorology, Nanjing University of Information Science & Technology, Nanjing, 210044, China
$^3$Applied Hydrometeorological Research Institute, Nanjing University of Information Science & Technology, Nanjing, 210044, China
$^4$Tianjin Meteorological Observatory, Tianjin, 300074, China

*Email: blue8724@163.com; Address: No.219, Ningliu Road, Nanjing, Jiangsu, 210044, China

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 $\Phi_m$ in China which one should be used in the PMP estimation equation. In this study, we proved the relationship between $K_m$ and $\Phi_m$. 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

$$K_m = \frac{x_{m} - x_{n-1}}{S_{n-1}}$$

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

$$x_m = (n-1)x_{n-1} + x_m$$

$$S^2 = \frac{1}{n-1} \sum (x_i - x_m)^2$$

where $x_m$ is the highest value of the series $X_1, X_2, \ldots, X_n$, $x_{n-1}$ and $S_{n-1}$ are, respectively, the mean and the standard deviation excluding the highest value from the series. $\bar{x}_m$ and $S_m$ are, respectively, the mean and the standard deviation of the series.

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

$$K_m = \Phi_m \sqrt{\frac{1}{C_1 - C_2 \Phi_m}}$$

(1)

The Conditions

(1) The minimum data size, $N_m$

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

(2) The stable data size, $N_s$

$$\frac{5.76(\Phi_m^2 + 2)}{N_s} \leq 3.5n$$

The sample error adjustment

$$\bar{x}_m = (1 + 3 C_{m,v}/\sqrt{n}) \bar{x}_m$$

Where $\bar{x}_m$ is the adjustment sample mean, $C_{m,v}$ 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:

$$X_{PMP} = \bar{x}_m + K_m S_m$$

(2)

Results

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Station</th>
<th>Year</th>
<th>$x_m$</th>
<th>$\Phi_m$</th>
<th>$\Phi_m$</th>
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</table>

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

d. 64 rain-gauge stations in Hong Kong and Shenzhen

Discussion and conclusions

- It proved that $K_m$ had an obvious statistical relationship with $\Phi_m$. 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.

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