# PREDICTION OF THE RETURN PERIOD OF DROUGHT IN PANJIAKOU HYDROLOGICAL STATION BY PEASON-III PROBABILITY DISTRIBUTION

by

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*Peason-III probability distribution is chosen to simulate monthly average runoff of Panjiakou hydrological station, and calculate the minimum value of monthly average runoff at different return periods throughout March, April, May, and the whole spring. The results show that minimum value of monthly average runoff was 85.59, 62.04, 50.24, 40.74, 30.33, 23.55, and 17.46 $m^3/s$ when return periods were fixed at 2, 10, 20, 50, 100, and 200 years, respectively. In addition, the fitting results were credible by comparing the observed return periods. The return periods of monthly average runoff of Panjiakou hydrological station in March, April, May, and the whole spring of 2001 were 147.00, 254.07, 1.80, and 34.07 years, respectively.*

Key words: *return period, Peason-III probability distribution, drought degree, curve fitting method*

## Introduction

The losses caused by meteorological disasters accounted for more than 70% of total losses caused by natural disasters [1]. In recent years, frequent burst and exacerbation of extreme weather events (such as floods, droughts, *etc*.) have already become the hottest topic of the society.

Peason-III probability distribution has a broad simulation capability, commonly used in meteorology to fit the monthly and annual maximum wind speed, the daily maximum precipitation and other extreme value distribution [2, 3]. Peason-III probability distribution is available to obtain the return period of a certain runoff and calculate the minimum runoff of a certain return period.

## Method

Peason-III curve equation is shown in eq. (1):

$$f(x)=\frac{\beta^{\alpha}}{\Gamma(\alpha)}(x-\alpha_0)^{\alpha-1}\mathrm{e}^{-\beta(x-\alpha_0)} \tag{1}$$

where $\Gamma(\alpha)$ is the gamma function of $\alpha$, parameters $\alpha$, $\beta$, and $\alpha_0$ have mathematical connection with mean $x'$, variation coefficient $C_v$ and skewness coefficient $C_s$ showing as:

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$$\begin{cases} \alpha = \dfrac{4}{C_s^2} \\ \beta = \dfrac{2}{x' C_s C_v} \\ \alpha_0 = x' \left(1 - \dfrac{2 C_v}{C_s}\right) \end{cases} \tag{2}$$

Thus the probability is greater than a maximum value $x_p$ can be obtained through eq. (3) [4, 5]:

$$C_s P(x \geq x_p) = \frac{\beta^{\alpha}}{\Gamma(\alpha)} \int_{x_p}^{\infty} (x - \alpha_0)^{\alpha - 1} \mathrm{e}^{-\beta(x - \alpha_0)} \mathrm{d}x \tag{3}$$

## Case study

**Table 1. Variation coefficient of March, April, May, and the whole spring**

| Time | March | April | May | Spring |
|---|---|---|---|---|
| $C_v$ | 0.37415 | 0.37538 | 0.41125 | 0.30767 |

Panjiakou hydrological station is located in northern China (118.28 E°, 40.43 N°). It belongs to Luan river of Haihe river basin. The water resource shortage in the Haihe river basin has become a growing problem in recent years. Therefore, monthly average runoff of March, April, and May from 1954 to 2001 in Panjiakou hydrological station was used to analyze the drought condition. Variation coefficient was shown in tab. 1.

Figure 1 displays Peason-III probability distribution of monthly average runoff ($Qm$) of March, April, May, and the whole spring at Panjiakou Station by using curve fitting method. It is obvious to see that the fitting curve is more consistent with the observed values when $C_s$ equals to $2C_v$.

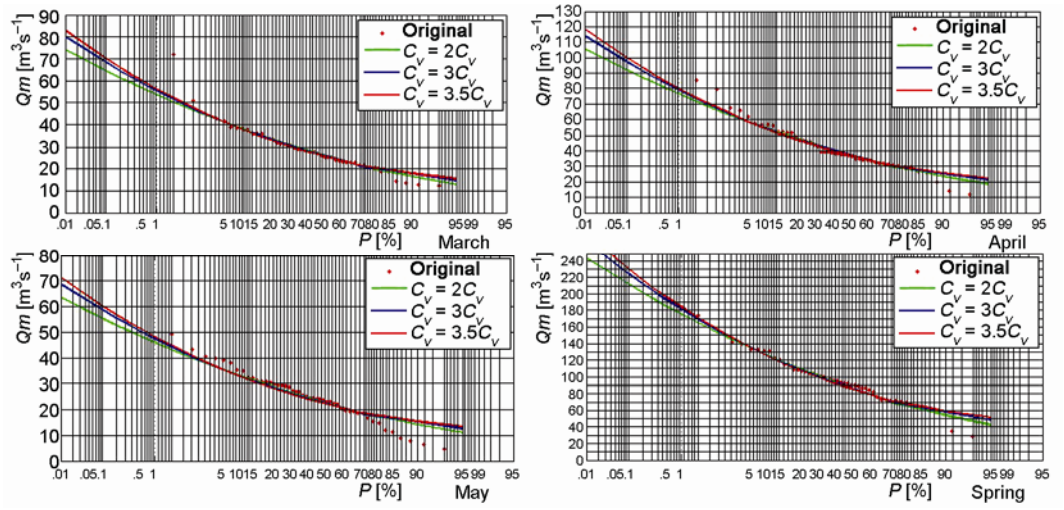


**Figure 1. Frequency calculation results of March, April, May, spring monthly average runoff at Panjiakou hydrological station**

After determining Peason-III probability distribution, it is easy to obtain the corresponding average monthly runoff of different return periods. We can see that monthly runoff tends to be smaller when the return period becomes longer from tab. 2.

The minimum monthly average runoff decrease when the return period increases shown in tab. 3. In March, if monthly average runoff is smaller than 20 $m^3/s$, then the estimated value of the return period is 4.81 years, and in fact there are 10 years in which monthly average runoff is less than 20 $m^3/s$ throughout 48 years, happening once every 4.8 years. The relative error is 0.2%. Table 3 shows that the estimation of the return periods is substantially identical to the observed return period. To some extent, applying Peason-III distribution to estimate the return periods of different drought degree and the drought degree under different return periods are creditable.

Table 4 shows that the drought of March and April in 2001 is indeed rare. Return period of drought in March is 147.00 years, in April reached 254.07 years, in May it reduced to 1.80 years because of adequate rainfall. However, the return period of drought in spring is 34.07 year.

**Table 2. The corresponding monthly average runoff of different return period**

| Return period | 2 | 5 | 10 | 20 | 50 | 100 | 200 |
|---|---|---|---|---|---|---|---|
| March | 26.65 | 19.82 | 17.29 | 15.67 | 14.27 | 13.56 | 13.04 |
| April | 38.58 | 26.89 | 21.5 | 17.4 | 13.16 | 10.54 | 8.28 |
| May | 22.84 | 16.53 | 14.16 | 12.62 | 11.28 | 10.59 | 10.08 |
| Spring | 85.59 | 62.04 | 50.24 | 40.74 | 30.33 | 23.55 | 17.46 |

**Table 3. Comparison results between observed return period and fitting return period**

| March | | | April | | |
|---|---|---|---|---|---|
| Monthly runoff [$m^3s^{-1}$] | Observed [year] | Fitting [year] | Monthly runoff [$m^3s^{-1}$] | Observed [year] | Fitting [year] |
| 20 | 4.8 | 4.81 | 20 | 16 | 12.64 |
| 25 | 2.52 | 2.32 | 25 | 9.6 | 6.22 |
| 30 | 1.71 | 1.6 | 30 | 4 | 3.67 |
| 35 | 1.33 | 1.3 | 35 | 2.67 | 2.48 |
| 40 | 1.09 | 0.89 | 40 | 1.71 | 1.86 |
| May | | | Spring | | |
| 20 | 2.82 | 2.72 | 30 | 48 | 51.64 |
| 25 | 1.78 | 1.69 | 50 | 16 | 10.16 |
| 30 | 1.26 | 1.33 | 70 | 4 | 3.44 |
| 35 | 1.14 | 0.9 | 90 | 2.09 | 1.78 |
| 40 | 1.04 | 0.52 | 110 | 1.34 | 1.26 |

**Table 4. Return period of monthly average runoff in spring of 2001**

| Month | March | April | May | Spring |
|---|---|---|---|---|
| Monthly runoff [$m^3s^{-1}$] | 14.34 | 14.06 | 24.07 | 52.47 |
| Return period | 147.00 | 254.07 | 1.80 | 34.07 |

## Conclusions

- Peason-III probability distribution has a better simulation capability to fit the distribution of monthly average runoff. Both minimum monthly average runoff of different return periods and return periods of different monthly average runoff can be obtained.
- The minimum value decreases when return period increases. In March, if monthly average runoffs are smaller than 20, 25, 30, 35, and 40 $m^3/s$, then estimated return periods are 4.81, 2.32, 1.6, 1.3, and 0.89 year. And in April, May and throughout the spring, the estimated return period is also similar to the observed return period.
- The return period of 2001 spring drought is calculated, indicating that drought condition of March and April 2001 is indeed rare. Return period of drought in March is

147.00 years, in April reached 254.07 years, in May it reduced to 1.80 years because of adequate rainfall. However, the return period of drought in spring is 34.07 year.

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