Analysis on the influence of upstream and downstream water levels of Puyang River on Meichi area

Chun Hu, Daoxin Chen, Huifang Guo

1 Wenzhou Vocational College of Science and Technology, Wenzhou 325006, China.
2 Zhejiang Tongji Vocational College of Science and Technology, Hangzhou 31123, China

*Corresponding author’s e-mail: 32970400@qq.com

Abstract. Meichi station is located in the lower reaches of Puyang River, where Puyang river forms a bucket shape. This place is affected by the upstream flood and the downstream tidal current, so it will be disastrous when it rains. In order to clarify the main causes of flood disaster at Meichi station, this paper analyzes the contribution of water level of Zhuji station in the upstream, Linpu station in the downstream and wenjiayan station on the top of Qiantang River to Meichi station. Through analysis, the downstream water level has the greatest impact on Meichi station. It is suggested that the downstream water level should be lowered as much as possible before the flood to reduce the impact of flood on Meichi area.

1. Introduction
Water conservancy is the foundation of all people's production and life, and flood disaster has always been a major problem perplexing people's production and life. Flood disaster has brought serious threat to people's life safety and property safety. Meichi area [1] is located in the lower reaches of Puyang River, with a special geographical location. Puyang river forms a bucket shape here. The flood in the upstream and the flood tide in the downstream have a very important impact on this area. When there is a flood in the upper reaches, the flood near the Meichi station is pushed by the downstream and cannot be discharged out, so it will be a disaster in case of rain.

In order to clarify the impact of the upstream and downstream on the Meichi lake, it is necessary to select the appropriate analysis object. Zhuji station is located in the upstream of Meichi station, which is one of the important water level stations in Puyang river. It is closer to Meichi station than other upstream water level stations. Therefore, Zhuji station is selected as the representative station of upstream influence of Meichi station. Linpu station is located in the downstream of Puyang River, which is one of the two important tidal level stations below Meichi station of Puyang river. It is close to Meichi station, so it is selected as the representative station of downstream influence of Meichi station. Wenjiayan station is located at the entrance of Puyang River into Qiantang River. It is mainly affected by Qiantang River tide and can represent the size of Qiantang River tide. Therefore, wenjiayan station is selected as the representative station of Qiantang River at Meichi station.

There are many methods of impact analysis, including expert scoring method, principal component analysis method, intelligent algorithm and so on. In this paper, human partial least squares method is used to determine the influence degree of each station on Meichi station. Partial least squares (PLS) [2-
4] is the integration and development of multiple linear regression, canonical correlation analysis and principal component analysis. The components extracted by PLS can not only summarize the information in the independent variable system, but also explain the dependent variables best. Therefore, it can be applied to extract the main influencing factors in Meichi area.

2. Multi scale analysis method

Due to its own characteristics, partial minimum bilevel method can determine the contribution degree of each variable [5-6]. Set the water level of Meichi station as the dependent variable $Y = \{y_1, y_2, L, y_n\}$ ($n$ is the total year, $y_i$ ($i = 1, 2, L, n$) is the water level value of a certain year). If the water level stations of Zhuji station, Linpu station and wenjiayan station are set as independent variables $X$, then:

$$
X = \begin{pmatrix}
  x_{11}, x_{12}, x_{13} \\
  x_{21}, x_{22}, x_{23} \\
  x_{31}, x_{32}, x_{33}
\end{pmatrix}
$$

(1)

Where $x_{i,j}$ is the water level value of the three stations, $i = 1, 2, L, n$ and $j = 1, 2, 3$ and $n$ is the total year. The water level matrix of Zhuji station, Linpu station and wenjiayan station $X_{n x 3}$ is the independent variable matrix, and the water level of Meichi station $Y_n$ is the dependent variable matrix, where $n$ is the number of years.

The factor matrix $X_{n x 3}$ and matrix $Y_n$ are standardized. Note that the standardized data matrix $X$ is the standardized data matrix $E_0 = (E_{01}, E_{02}, E_{03})_{n x 3}$. The purpose of standardization is to make the center of gravity of the set of sample points coincide with the origin of coordinates.

The first component $E_0$ recorded is $t_1$, $t = E_0 w_1$, which $w_1$ is a unit vector, that is $\|w_1\| = 1$, it represents the first axis of interpretation $E_0$; the first component recorded is $F_0$, is the first axis of $u_1$, $u_1 = F_0 c_1$ and $\|c_1\| = 1$.

Requirements $t_1$, $u_1$ can express the data variation information of, respectively $X$, $Y$ and $t_1$ have the maximum ability to explain $u_1$. According to the principle of principal component analysis and canonical correlation analysis, it is necessary to:

$$
Var(t_1) \rightarrow \text{max}
$$

(2)

$$
Var(u_1) \rightarrow \text{max}
$$

(3)

$$
r(t_1, u_1) \rightarrow \text{max}
$$

(4)

Where $Var(\cdot)$ is the variance and $r(\cdot)$ is the correlation coefficient. When the two ideas $t_1$ and $u_1$ are combined, even if the covariance of sum is the largest.

$$
Cov(t_1, u_1) = \sqrt{Var(t_1)Var(u_1)}r(t_1, u_1) \rightarrow \text{max}
$$

(5)

The above equation can be expressed as the following optimization problem:

$$
\max \{E_0 w_1, F_0 c_1\}
$$

s.t.

$$
\begin{align}
    w_1^T w_1 &= 1 \\
    c_1^T c_1 &= 1
\end{align}
$$

(6)
Where $\langle \cdot \rangle$ is the inner product operator, and the upper formula is the maximum value $w^TEF^Tc$ under the constraint of $\|w\| = 1$ and $\|c\| = 1$. Lagrange algorithm is used to solve the problem. The regression equation of Meichi station water level $Y$ with respect to the water level of Zhuji station, Linpu station and wenjiayan station $X$ can be obtained

$$Y = XB^*$$

According to the regression coefficient, the contribution degree of water level of each station in water demand factor to Meichi station water level $Y$ can be determined, so as to determine the influence factor of each station to Meichi station.

3. Partial least squares analysis results
The selected data of Meichi, Zhuji, Linpu and wenjiayan stations from 1955 to 2011 are analyzed by partial least square method. The data of Zhuji, Linpu and wenjiayan stations are recorded as $X$ and the data of Meichi station are recorded as $y$. The data of $X$ and $y$ are standardized according to the following formula: record $X$ and $Y$, respectively, the data matrix $x$ and $y$ after standardization:

$$X_i = [x_i - E(x_i)] / S_x \quad (i = 1, 2, 3)$$

$$Y = [y - E(y)] / S_y$$

(8)

Where, $E(x_i)$ and $E(y)$ are the mean value of $x_i$ and $y$, $S_x$ and $S_y$ respectively the mean square deviation of $x_i$ and $y$. Next, the partial least squares method was used to analyze the correlation between the components

| Table 1. Table of correlation among various factors |
|-----------------------------------------------|
| r                | zhuji | wenjiayan | linpu | meichi |
|------------------|-------|-----------|-------|--------|
| zhuji            | 1     | 0.226857  | 0.547378 | 0.817447 |
| wenjiayan        |       | 1         | 0.903728 | 0.61223  |
| linpu            |       |           | 1     | 0.848739 |
| meichi           |       |           |       | 1       |

Where $0.5 \leq |r| < 0.8$ is significant linear correlation, and $0.8 \leq |r| \leq 1.0$ is highly linear correlation. It can be seen from the above table that Linpu station has the greatest correlation with Meichi station, next is actually Zhuji station and finally wenjiayan station. The importance of variable $x$ in explaining dependent variable $y$ is shown in the table below

| Table 2. Importance of each station to Meichi station |
|-----------------------------------------------------|
| variables      | Importance |
|----------------|------------|
| zhuji          | 1.029905   |
| wenjiayan      | 0.806509   |
| linpu          | 1.13527    |

According to the table above, Linpu station is the most important station for Meichi station, followed by Zhuji station and wenjiayan station.

4. Conclusion
In this paper, the partial least square method is used to determine the weight of Meichi station, which is represented by Zhuji station in the upstream, Linpu station in the downstream and wenjiayan station in Qiantang River flood tide. According to the calculation results, Linpu station, Zhuji station and wenjiayan station are the most seriously affected stations. Therefore, in order to solve the flood disaster of Meichi station, it is necessary to reduce the downstream water level. The downstream water level is mainly determined by the flood volume of each tributary of Puyang River converging to Puyang river. Therefore, the control water conservancy project can be built in each tributary of Puyang River to reduce...
the flood volume in the downstream. Secondly, it is necessary to control the discharge of the upper reaches by changing the discharge mode of the main large and medium-sized reservoirs in the upstream, increasing the storage capacity and adjusting the discharge time. At last, the flood tide can be reduced by adjusting the discharge of the upper reaches of Qiantang River, and the flood of Puyang River and Qiantang River can be staggered to reduce the flood disaster in Meichi area.

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