Dear anonymous referee #1,

Thank you very much for detailed reading of our manuscript and providing us with your comments. We will improve the presentation in the revised manuscript. Now we revise the paper according to the following comments.

Major points:

Q*:* All Figure captions need to contain more information about what is displayed in the figure.

A: Agree. We will revise the captions as follows.

1) Fig. 1. Location map of the study area and its terrain map showing district boundaries along with the complex river network.

2) Fig. 2. River network model established by HEC-RAS with 3 pump stations, 7 tide-locks and 2 check gates.

3) Fig.3 District division for flood drainage and its units numbering in Fuzhou city by the 5-m digital elevation model (DEM).

4) Fig.4 Surface runoff process and pipeline outflow process of a drainage unit in the urban area.

5) Fig.5 Observed data of the flooded parts of the rivers in Fuzhou city during Typhoon Longwang.

6) Fig.6 Simulation results of the flooded parts of the rivers in Fuzhou city during Typhoon Longwang.

7) Fig. 7 Comparison of level hydrographs between the observed data and the simulation results at the midstream of Jinan River.

8) Fig. 8 Isolines representative of an equal percentage of flooded length presented as a function of 24-h rainfalls and tidal levels in two conditions: (subfigure (a): without pumps working; subfigure (b): with pumps working). “Start” represents the threshold condition that flood just occurs. “25%” and “50%” represent the ratio of the length of the flooded parts to the length of the rivers in total.

9) Fig. 9 Isolines representative of an equal percentage of flooded length presented as a function of 24-h rainfalls and tidal levels return periods in two conditions:(subfigure (a): without pumps working; subfigure (b): with pumps working).

10) Fig. 10 Comparison of the threshold condition that flood just occurs between without pumps working condition and with pumps working condition.

11) Fig. 11 Correlation between empirical joint distribution and theoretical joint distribution for the observed combinations of 24-h rainfalls and tidal levels. “R^2” represents the square of the linear correlation coefficient between empirical frequency and theoretical frequency.

Q: sec. 3.3 More explanation is needed. Not many people are familiar with copulas. Explain what they are, and especially explain the specific copulas that you mention (Gaussian, t, Clayton, etc.)

A: The explanations about copulas are given in the next paragraphs, and they will be added in section 3.3, page 7482.

A copula is a kind of distribution function. The cumulative distribution function of a random vector can be written in terms of marginal distribution functions and a copula. The marginal distribution functions describe the marginal distribution of each component of the random vector and the copula describes the dependence structure among the components. According to Sklar (Sklar, 1959), for a cumulative joint distribution function H for 2-dimensional continuous random variables, supposing its margins are continuous, there is a copula function C that makes $H(x, y) = C(F(x), G(y))$, where F and G are the marginal distribution functions. The widely used copula functions include Gaussian copula, t-copula, Clayton copula, Frank copula and Gumbel copula. They are introduced as follows.

Gaussian copula is:

$$C(u,v) = \int_{-\infty}^{\Phi^{-1}(u)} \int_{-\infty}^{\Phi^{-1}(v)} \frac{1}{2\pi\sqrt{1-\rho^2}} \exp\left(\frac{-(r^2+s^2-2\rho rs)}{2(1-\rho^2)}\right) \mathrm{d}r\mathrm{d}s, \quad \rho \in (-1,1).$$

$\Phi^{-1}(.)$ is the inverse function of the standard normal distribution function $\Phi(.)$, and ρ is the linear correlation coefficient between $\Phi^{-1}(u)$ and $\Phi^{-1}(v)$.

The *t*-Copula is:

$$C(u,v,\rho,\nu) = \int_{-\infty}^{T_\nu^{-1}(u)} \int_{-\infty}^{T_\nu^{-1}(v)} \frac{1}{2\pi\sqrt{1-\rho^2}} \exp\left(1+\frac{r^2+s^2-2\rho rs}{\nu(1-\rho)^2}\right)^{-\frac{\nu+2}{2}} \mathrm{d}r\mathrm{d}s, \quad \rho \in (-1,1)$$

$T_\nu^{-1}(.)$ is the inverse function of the distribution function $T_\nu(.)$ with the degree of freedom of ν, and ρ is the linear correlation coefficient between $T_\nu^{-1}(u)$ and $T_\nu^{-1}(v)$.

The Clayton copula is:

$C(u,v) = (u^{-\theta} + v^{-\theta} - 1)^{-1/\theta}, \quad \theta \in (0,\infty)$, where θ is the parameter.

The Frank copula is:

$C(u,v) = -\frac{1}{\theta} \ln[1 + \frac{(e^{-\theta u}-1)(e^{-\theta v}-1)}{e^{-\theta}-1}], \quad \theta \in R \setminus \{0\}$, where θ is the parameter.

The Gumbel copula is:

$C(u,v) = \exp\{-[(-\ln u)^\theta + (-\ln v)^\theta]^{1/\theta}\}, \quad \theta \in [1,\infty)$, where θ is the parameter.

Q: p 7485, l 19-25 A better explanation is needed. What precisely is depicted in the figure? Does the figure mean that for precipitation return times of more than 20 years pumping is useless? Would stronger pumps help?

A: The explanation of figure 10 is given in the next paragraphs, and it will be added in section 4.2, page 7485.

In the Fig.10, threshold condition that flood just occurs is presented as a function of rainfall and tidal level return periods. The red line and the black one are the isolines of threshold condition with or without pumps working respectively. As Fig.10 shown, pumps with a maximum flow rate of 250 m^3/s can take effect on flood drainage for a rainfall less than 100 yr, especially for a rainfall less than 20 yr. For example, the corresponding tidal level for flood is 25.8 yr in pumping condition for the rainfall of 5 yr return period. And it is just 3.3 yr without pumping. However, for the rainfall of 100 yr return period, the corresponding tidal levels both are 1.0 yr.

The heavier the rainfall is, the more water volume for drainage is. When the surface runoff of a rainfall that gathers and flows into a river or be drained by pipelines is more than the flow capacity of the river channel in Fuzhou city, flood happens in a local area. In this situation, pumps with a certain capacity located in the downstream of a river network just have a limited effect on reducing flood. Stronger pumps may still not help.

For Fuzhou city, 100 yr is a critical value with the pumping capacity of 250 m^3/s. When the precipitation is lower than it, pumping is useful, if not, pumping is useless. Once the pumping capacity increases, the critical value that pump could not play a part in flood drainage will be also increase but it always exists. For other cities, the critical value also exists but probably is different. So for a city, stronger pumps would help flood drainage to some extent.

Q: p 7486, l 17 What is the meaning of the fact that the Gumbel copula works best?

A: In Tab. 1, the test statistic *D* of K-S test of Gumbel copula is 0.0602, and the *OLS* of Gumbel copula is 0.01603, they are both the smallest in all copulas in the table. That means the Gumbel copula could better fit the joint distribution of the precipitation and the tidal level.

Q: p 7486, l 20-23 I cannot see why (6) follows from (3). Where are f_h and f_z?

A: The explanation of how the Eq. (6) follows from (3) is given as follows. We will add the relevant formulas in section 3.3, page 7483.

The Gumbel copula is: $C(u,v)=\exp\{-[(-\ln u)^{\theta}+(-\ln v)^{\theta}]^{1/\theta}\},\quad \theta\in[1,\infty)$. For the variables precipitation *H* and tidal level *Z*, the joint distribution function is:

$F(h,z)=\exp\{-[(-\ln F_h(h))^{\theta}+(-\ln F_z(z))^{\theta}]^{1/\theta}\}$. The parameter θ is calculated by the Maximum Likelihood Function, which is derived from the density function (Eq. (3)).

Q: p 7487, l 1-7 Please explain the columns in Table 2.

A: Explanation of the columns in Table 2 will be added in section 4.3.3, page 7487.

The column named "Maximum annual 24 h rainfall" contains 3 columns, "*H*(mm)", "*P*(%)", and "*T*(a)". *H* is the maximum annual 24-h rainfall. *P* is the exceedance probability of the rainfall. T is the return period of the rainfall. The column named “Corresponding tidal level” contains 4 columns, “Z(m)”, “P(%)”, “P_M(%)”, and “T_M(a)”. Z is the tidal level when the maximum annual 24-h rainfall happened (corresponding tidal level). P is the exceedance probability in the probability distribution of the corresponding tidal levels. P_M is the frequency of the corresponding tidal level in the probability distribution of annual maximum tidal level series. The return period of the corresponding tidal level is T_M, which is the reciprocal of P_M.

Q: p 7487, l 18/19 So this means that a high tidal level is usually accompanied by heavy rain and vice versa? Seems obvious: It rains heavily during a storm (or typhoon) that transports moist air from the ocean to the land, and the same wind creates a surge, increasing the tidal level. Why do you need a complicated mathematical method (EVT) to conclude this?

A: Probably not. In the page 7487, line 10, we point out the probability that high tidal level and heavy rain occur at the same time is very low. It can be seem in column 9 of the Table 2. The column $P\bigcap(h,z)$ shows that the joint probability of 5-yr rainfall and 2-yr tidal level is 0.5017%, and with the increase of the return period of rainfall and tidal level, the joint probability is getting smaller. This means when heavy rain happens, the high tidal level barely comes up. So for Fuzhou city, a high tidal level is not usually accompanied by heavy rain, which is different from some other coastal cities. That is why we need a complicated mathematical method to make a quantitative analysis.

For Fuzhou city, the design standard of flood defense is derived only by the rainfall considered, ignoring the extra risk posed by tidal level. Therefore, even though the probability that the heavy rain and the high tidal level occur at the same time is very low, the combined probability that at least one variable exceeds a certain standard (denoted as $P\bigcup(h,z)$) is larger than the probability that one of them exceeds. Emphasis in the paper is that the combined probability and combined effect of multivariate for a quantitative risk value should be considered to determine the flood design standards and to manage the risk.

Q: p 7488, l 12-14 This seems rather obvious. But what is the consequence? You have shown that sea level poses an extra risk. So how to cope with sea level? Higher dykes?

A: Yes, the sea level poses an extra risk. So firstly, it should analyze the combined return period of the rainfall and the tidal level to determine the design standard of the defences. If the capability of current defences cannot get to the design standard, higher dykes would be a solution to cope with the extra risk. Secondly, reasonable scheduling rules of tide-locks and pumps are effective measures to reduce the risk.

The consequence will be added in section 5, page 7488.

Minor points:

p 7476, l 11 diverse → different

A: Agree. We will correct it in the revised manuscript.

p 7479, l 2-4 refer here to Fig. 1

A: Agree. We will correct it in the revised manuscript.

p 7480, l 3 explain DEM

A: Explanation of DEM will be added in section 3, page 7480.

The DEM refers to the 5-m DEM (Digital Elevation Model) of Fuzhou City on the scale of 1:10000 produced by Fujian Bureau of Surveying, Mapping and Geoinformation (FBSMG).

p 7481, l 7 rest → remaining

A: Agree. We will correct it in the revised manuscript.

p 7481, l 16 reference needed for Reasoning Formula Method

A: Reasoning Formula Method will be replaced by rational formula method in section 3.1.1, page 7481.

The reference will be added as follows.

Guo, J.: Rational Hydrograph Method for Small Urban Watersheds, J. Hydrol. Eng., 6, 352–356, doi: 10.1061/(ASCE)1084-0699(2001)6:4(352), 2001.

p 7483 Make equations part of the sentence instead of listing them at the end of the sentence.

A: Agree. We will correct it in the revised manuscript.

p 7486, l 21 Make equation part of the sentence.

A: Agree. We will correct it in the revised manuscript.

p 7487, l 10+20 slight → low

A: Agree. We will correct it in the revised manuscript.

Figs. 5+6 The information content of these figures is rather low. It is hard to find any differences. Perhaps it will be better to show a difference plot only.

A: Yes, it is hard to find differences in the Figure 5 and Figure 6, but this is just a proof that the hydrological model can be used to analyze the flood severity. The two figures will be merged into one figure for a clear comparison of flood severity between observed data and simulation results.

Fig. 7 At which location?

A: Figure 7 is the comparison of level hydrograph at the midstream of Jinan River, where has a real-time observed data of water level. We will present clearly in the revised manuscript.

Fig. 8 What does the value 25% mean? 25% of what?

A: “25%” represents the ratio of the length of the flooded parts to the length of the rivers in total.

Reference:

Sklar, A.: Fonctions de répartition à n dimensions et leurs marges, Publ. Inst. Statist. Univ. Paris, 8, 229–231, 1959.