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Flood Submerging Simulation in small watershed of hilly regions

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Abstract. In this paper, we took three watersheds as the study object where were located in Liucheng Town, Licheng District. We simulated the the flood submergence process under different calculation schemes by using MIKE11 simulation software to establish the mathematical model of the study area, based on the field measurement data and collected data. We analyzed the effect of flooding in various magnitudes from the assessment of flood control status of mountain flood disasters in small watersheds, combining with the flood submerged simulation results of different magnitudes in small watersheds and the calculation results of submerged water level and water depth. Simulation results show that the Mike11 NAM and HD coupling model can simulate rainfall runoff and river network flow in small watershed well, providing technical support for the simulation of small watershed flood.

1. Introduction

In recent years, the impact of extreme weather, the flood disaster in the world is common news. Its wide range of coverage makes it the focus of attention of governments and researchers. In order to improve the ability of cities to cope with rainstorm and flood disasters, domestic and foreign researches on urban rainstorm and flood disasters have gradually shifted from focusing on the causes of disasters and disaster mathematical statistics methods to paying attention to real-time dynamic changes of disasters and high-precision analysis methods based on scenario simulation [1]. In this paper, the model of rainfall runoff NAM and hydrodynamic model HD coupling model in MIKE 11 series software are used to simulate the rainstorm - flood in the basin.

2. Overview of research area

The research area is located in the southeast of Li Cheng district, which in Liu Bu town, Li Cheng district. Climate in the study area is typical continental monsoon climate characterized. Dry spring less rain, more southwest, southerly wind; Hot and rainy in summer; Autumn days high air, autumn temperature than spring temperature; Winter is long and cold and dry, with frequent northeast wind [2]. The average annual precipitation is 665.7 mm.

This article mainly to Zhen Town teachnolosy of willow port stations of three small watershed in detail research, where the river as the parts of Jin Yang river, which includes part of the water of long valley (trunk), Tao Ke river and water of Qi Cheng river, the following respectively the main river, Tao Ke river and Qi city, name and the matching of small watershed. The research scope of trunk flow is the section from the source to the lower reaches of the middle village of Liu Bu town. The river length is 18.57km and the catchment area is 53.42km². The total length of the Tao Ke river is 10.7km and the basin area is 44.94km². Qi Cheng river is 8.72 km, the basin area of 22.03 km².



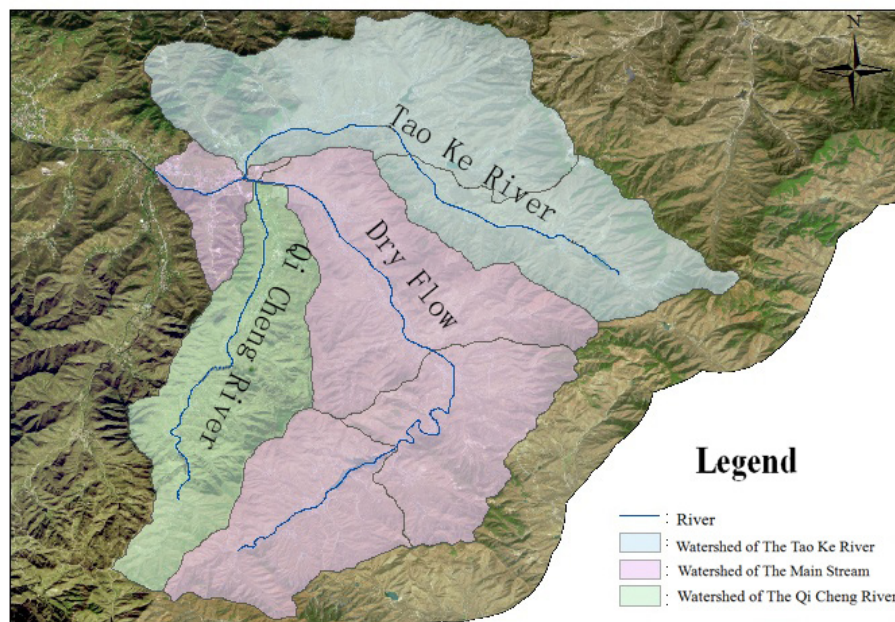


Figure 1. Distribution map of water system and watershed in the study area.

3. The construction of production confluence model

3.1. NAM model construction

NAM model is one of the many Rainfall Runoff simulation methods included in the MIKE 11 RR (Rainfall-Runoff) module. It is a centralized, conceptual model used to simulate Rainfall and Runoff processes in natural river basins [3]. In the NAM module, the production and confluence process was simulated by the water quantity of four mutually affected water reservoirs, including the plant soil root zone and the surface layer [4]. The NAM model consists of the following steps: watershed information properties page, NAM model properties page, time series file page.

3.2. Establishment of HD model

MIKE11 HD need 4 files to model, which are river network files, section files, boundary files and HD parameter files [5]. The model structure diagram is shown in figure 2.

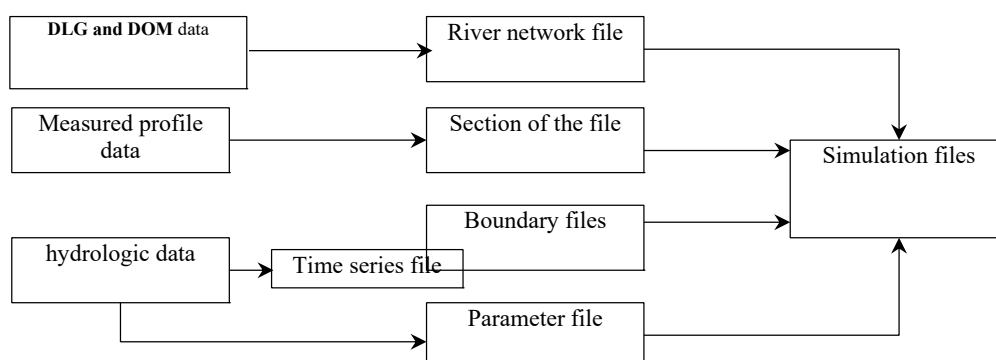


Figure 2. Structure diagram of HD model.

3.3. NAM model and HD model are coupled

MIKE11 can realize the coupling of rainfall runoff (NAM) model and hydrodynamic model (HD) to provide a model basis for river flood evolution simulation. [6]. The runoff of a river basin can be imported into the river network in both linear and non-linear ways, and can be controlled by setting the upstream and downstream mileage of the connected river channel. The three small watershed areas involved in this study were all transferred into the river network in the form of line source. The specific setting is shown in table 1.

Table 1. NAM and HD coupling Settings.

The name of drainage basin	area	Imported river	Upstream mileage	Downstream mileage	Type of import
drainage basin of Main stream Tao Ke	53.42	main stream	0	16266	Line source
drainage basin Qi Cheng	44.94	Tao Ke river	0	10749	Line source
drainage basin	22.03	Qi Cheng river	0	8720	Line source

4. Model calibration and verification

In this paper, the parameter rate timing is mainly used to combine the model automatic rate determination function with the manual fine adjustment method. According to the collection of the rainfall data of the two rainwater stations since 1976, and the data of three storms in 19940629, 20000809 and 20130723, which were seriously affected by mountain flood disasters, were selected into time series for the determination of model parameters. Limited by the regional measured data, the basin lacks runoff series data. Therefore, for the acquisition of the river basin export flow process line, this paper uses the hydrological calculation formula method to estimate. The runoff and convergence processes in each basin are calculated using the rainfall-runoff correlation method.

5. Simulation and analysis

The establishment of the coupled model provides a model basis for the simulation of the flood evolution process in small watersheds. In order to predict the impact of different magnitude floods on small watersheds, Through the comprehensive consideration of flood sources, flood magnitudes and flood combination methods, five different flood simulation calculation schemes were developed, as shown in Table 2. The different schemes were simulated by mike11, and the corresponding results were analyzed, which provided theoretical basis and data support for flood control evaluation of small watershed.

Table 2. flood simulation scheme design

Scheme number	Design					
	Main stream		Tao Ke river		Qi Cheng river	
	Rainstorm frequency	Flood return period	Rainstorm frequency	Flood return period	Rainstorm frequency	Flood return period
One	20%	Once in five years	20%	Once in five years	20%	Once in five years
Two	10%	Once in ten years	10%	Once in ten years	10%	Once in ten years
Three	5%	Once in twenty years	5%	Once in twenty years	5%	Once in twenty years

Table 2. flood simulation scheme design

Scheme number	Design					
	Main stream		Tao Ke river		Qi Cheng river	
	Rainstorm frequency	Flood return period	Rainstorm frequency	Flood return period	Rainstorm frequency	Flood return period
Four	2%	Once in fifty years	2%	Once in fifty years	2%	Once in fifty years
Five	1%	Once in a hundred years	1%	Once in a hundred years	1%	Once in a hundred years

1) The dynamic results of the simulated water level in the flood season of different river sections along the 100th year are shown in Figures 3~5. It can be seen from the simulation results that the shape of the main stream and the tributaries of each tributary have been reduced with the change of river topography, and there is no irrational phenomenon such as high and low, which is consistent with the law of river flood evolution. The study also carried out a comparative analysis of the flood simulation results of different magnitudes. It can be seen that the flooded surface line gradually increases with the increase of the flood level, but the dynamic change of the increase is not obvious.

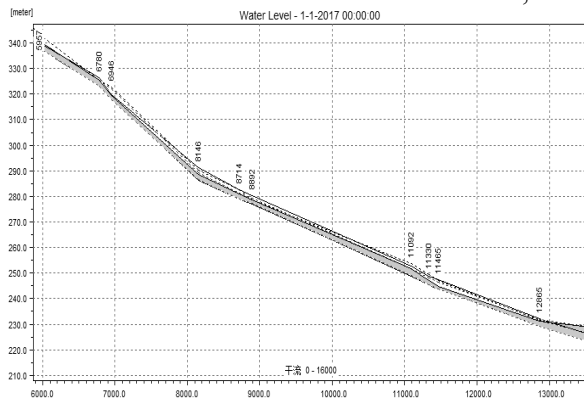


Figure 3. Simulated surface diagram of dry flow at the order of magnitude of once-in-a-century flood.

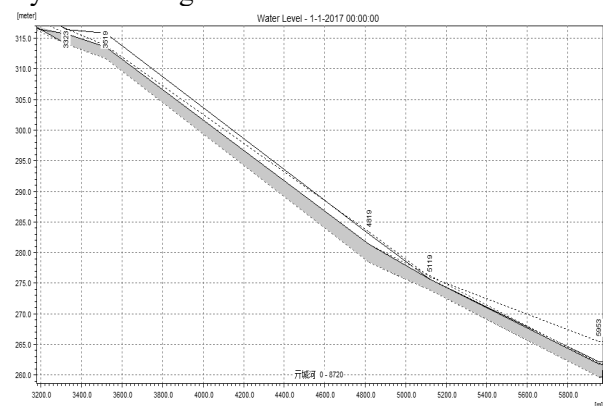


Figure 4. Simulated surface diagram of Qi Cheng river at the order of magnitude of once-in-a-century flood

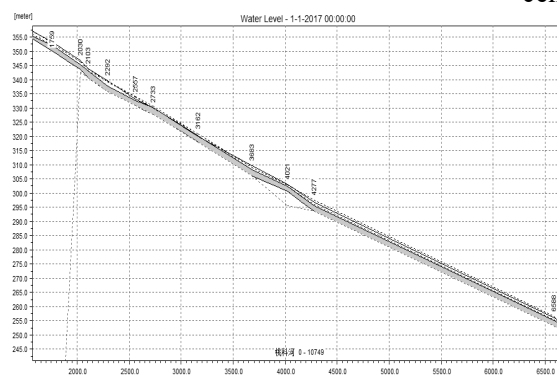


Figure 5. Simulated surface diagram of Tao Ke river at the order of magnitude of once-in-a-century flood.

2) The calculation results of flood peak flow and maximum flood level of typical villages in different watersheds are shown in Table 3. It can be seen from Table 3 that as the flood level increases, the highest water level of each section increases, and the flood peak flow increases gradually. The typical flood section of Liu Buzhong Village at the intersection of rivers has a flood peak flow of 1000m³/s. And the greater the flow rate, the higher the water level.

Table 3. Results of calculating flood peak flow and maximum water level of each typical section under different schemes.

Serial number	river	Village name along the river	Once in five years		Once in ten years		Once in twenty years		Once in fifty years		Once in a hundred years	
			$Q_{\max}$ (m^3/s)	$H_{\max}$ (m)	$Q_{\max}$ (m^3/s)	$H_{\max}$ (m)	$Q_{\max}$ (m^3/s)	$H_{\max}$ (m)	$Q_{\max}$ (m^3/s)	$H_{\max}$ (m)	$Q_{\max}$ (m^3/s)	$H_{\max}$ (m)
One	Qi Cheng river	Qi Cheng Village	40	275.24	57	275.51	79	276.07	113	276.35	143	276.53
Two	Main stream	Dai Mian Village	130	247.6	210	248.1	314	248.66	467	249.56	545	250.04
Three	Tao Ke river	Tao Ke Village	37	351.34	57	351.62	84	351.93	128	352.36	162	352.65

3) The submerged water depth of typical villages in each basin under different calculation schemes is shown in Table 4. It can be seen from Table 3 that as the flood level increases, the submerged water depth of each section gradually increases, and the water depth of some sections is more than 4.5 m. The main stream and the submerged water depth of each tributary do not show obvious regularity from upstream to downstream, which is related to the large terrain fluctuation of the hill area and the natural shape of the river section.

Table 4. Results of calculation of flood depth of each typical section under different calculation schemes

Serial number	river	Village name along the river	River bottom elevation (m)	Submerged water depth (m)				
				Once in five years	Once in ten years	Once in twenty years	Once in fifty years	Once in a hundred years
1	Qi Cheng river	Qi Cheng Village	273.618	1.622	1.892	2.452	2.732	2.912
2	Main stream	Dai Mian Village	245.021	2.179	2.679	3.239	4.439	4.619
3	Tao Ke river	Tao Ke Village	350.087	1.253	1.533	1.843	2.273	2.563

6. Conclusion

The MIKE 11 model software was used to construct the river basin production and flow model and the river hydrodynamic model, and the two were coupled to form a one-dimensional river channel flood evolution model. The coupling model was used to simulate the flood evolution process under five different calculation schemes. The dynamic results of different flooding submerged water surface lines, the flood peak flow and flooding water level results of each section and the submerged water depth results of each section were obtained. The overall simulation effect of the model is credible, and it has good applicability in the process of rainfall and flood in the small watershed in the hilly area where the data is lacking. It can be seen from the simulation results that the results are consistent with the law of river flood evolution. It can provide certain data support and reference basis for flood control evaluation and early warning work in the region.

Acknowledgments

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