Research on Flood Disaster Simulation of Hongqi River Basin Based on HEC-RAS

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Abstract. At present, flood disasters are one of the main natural disasters in the world, and the research on flood disasters in current geography is also a research hotspot in recent years. Floods pose a serious threat to people's lives and properties such as farmland and urban areas. Research on flood simulation can help reduce such losses to a certain extent. This paper takes the Hongqi River Basin in the upper reaches of the Tumen River as the research area, applies the Terrain Digital Elevation Model (DEM), uses the HEC-RAS model, and combines the HEC-GeoRAS module under the ArcGIS platform to build on the Tumen River as the terrain is more complicated. The hydrodynamic simulation of flood water flow when flood disaster occurs in the river basin, the rough visual analysis of the flood situation in the Hongqi River Basin, and the comparison and analysis with the measured data, will be used for future flood control early warning, disaster assessment, and Project site selection and other work provide reference data. The simulation analysis shows that HEC-RAS has a good simulation effect in this area and can provide decision support for flood prevention and control.

Keywords: HEC-RAS; HEC-GeoRAS; flood simulation; ArcGIS.

1. Introduction
In recent years, due to the dual impact of global climate change and human activities, the frequency of extreme weather has gradually increased, and the occurrence of extreme floods has become more frequent, causing significant losses to people's lives and properties. For example, in 2018, there were 39 heavy rainfalls in China. A total of 35.262 million people were affected by floods and other disasters, and 1.42 million people were urgently transferred and resettled [1].

Flood simulation plays an important role in flood control forecasting, emergency rescue planning, and mitigation of losses caused by flood disasters. It can provide scientific basis for flood warning, evacuation planning, loss assessment, and formulation of targeted flood control measures. Scholars at home and abroad have also applied this model to practice: Mu Xiping conducted a study on the flood evolution law of the flood protection area based on HEC-RAS, constructed a dyke break flood model in the study area, and calibrated it based on the existing inundation data in the study area. The accuracy of the built model was verified, and the model was built to meet the accuracy requirements, which can be used to analyze the flood evolution law in the study area [2]; He Juan et al. used the HEC-RAS model to simulate the flood break of the Changheba Reservoir on the Dadu River, and the simulation found the dam disaster caused the inundation range and the maximum flow velocity in the downstream area,
which helped to draw the flood disaster risk map [3]; based on the HEC-RAS model and the Regional Hydrological Forecast System (RHEPS), the Delaware River Basin was flooded within seven days by Michael Gomez and others. The forecast result shows that the flood forecast after the coupled hydraulic model is more accurate. So many successful precedents indicate that the application of the HEC-RAS model in flood simulation will be more extensive in the future.

2. The study area
Tumen River originates from the southeast of Changbai Mountain. It is the second largest river in Jilin Province and the border river between China and North Korea. It stretches from west to east along the border between China and North Korea, flows through Tumen City, and finally flows southeast into the Sea of Japan. The total length of the main stream is 525 kilometers, and the total river bed drop is about 1,200 meters. The region belongs to a humid monsoon climate in the mid-temperate zone. The average rainfall is generally 400-650 cubic centimeters, and the upper reaches reach 1000-1500 cubic centimeters. The annual rainfall is mainly concentrated in June, July and August, accounting for 60% of the total annual rainfall. %, it is easy to form a flood. The main mountain ranges include Panling, Harbaling, Nangang Mountain, Zengfengling, Ying'eling, etc. The Hongqi River originates from the southern foot of Zengfengling in Helong City, and flows eastward through Longcheng and Chongshan villages and towns in Helong City. Along the way, it receives the Damalugou River and the Xiaomalugou River, and it is injected into the Tumen River near the ancient city of Chongshan Town, with a total length of 65.8 kilometers and a drainage area of 1,199 square kilometers [4].

3. HEC-RAS model simulation
The HEC-RAS flood simulation software was jointly developed by the U.S. Army Corps Hydrological Engineering Center and the U.S. Environmental Research Institute (ESRI). It can simulate the constant flow and unsteady flow of the river surface line, and perform water quality analysis and sediment transport calculations. This article selects the latest version of HEC-RAS 5.0.7 and HEC-GeoRAS in ArcGIS for research. HEC-Geo RAS can consider the influence of hydraulics, sediment transport, river roughness and related boundary conditions, and combine the remote sensing images under the ArcGIS platform to extract the spatial geometric data required by the HEC-RAS model.

3.1. HEC-GeoRAS
The powerful flood analysis and calculation functions of HEC-RAS can be widely used in river management and flood forecasting. However, economic conditions limit the collection of river data obtained by monitoring, so the collection cost is huge, and it is very difficult to measure the channel and cross-section information in the floodplain, which makes it difficult for us to obtain the boundary conditions of the terrain data and limits the performance of HEC-RAS [5]. Geographical information system can solve the above-mentioned problems well through remote sensing technology and satellite surveying and mapping technology. Therefore, ESRI and HEC jointly developed the HEC-Geo RAS module. Through this module, the terrain data required for simulation can be obtained from the DEM or TIN data of the research basin, such as the river course, the river cross section, the distance between the measuring station and the section, and Extract the potential surface conditions from it, and the land use type map obtained through remote sensing technology. As a data bridge between HEC-RAS and ArcGIS platform, HEC-GeoRAS provides data processing functions before and after analysis, and improves the efficiency of HEC-RAS[6].
3.2. **HEC-RAS simulation**

The main operation process of the simulation is as follows: (1) Import the digital terrain elevation data (DEM) into ArcGIS, and use the HEC-GeoRAS module for pre-processing to create river water surface centerline, river bank line, water flow path line, river cross section and river Dam layer, add and extract river section name, section length, elevation and roughness data (Manning coefficient) to the created layer as shown in Figure 1. (2) Export the preprocessed river section data from ArcGIS, and import the exported .sdf format file into the HEC-RAS software to edit the geometric attributes of the river network. These attributes mainly include: the shape of the river network, the direction of the river section, the cross section of the river, and the Manning coefficient of different land use types in the study area. Check the runoff situation of the drawn river cross section in HEC-RAS (Figure 2). According to needs, you can also add hydraulic structures, such as dams, dikes, etc. (3) Adjust the boundary conditions, underlying surface conditions and initial conditions of the model according to the historical series flow data of the monitoring sections of the river course, and describe the runoff generation model in the study.
area. (4) Bring in the historical flood data of the monitoring section sequence, conduct steady flow simulation, and obtain the flow simulation of the river course in the study area under the conditions of a specific time period and time step, and compare it with the actual monitored flow as shown in Figure 3.

4. Conclusion
Using the HEC-RAS model and the ArcGIS-based HEC-Geo RAS module to couple, establish the HEC-RAS model for the Hongqi River basin in the upper reaches of the Tumen River and simulate the inundation area when the area encounters floods. The main conclusions obtained are as follows:

(1) Through the use of DEM data and GIS technology, the flood simulation calculation of HEC-RAS can improve the efficiency of flood modeling, and simulate the real scene of flood inundation in this area more realistically. The results are ideal and have high applicability. The results are visualized. After determining the flood inundation area based on the flood level, the land use type and economic data can be combined to quickly evaluate the forest land, arable land, residential land, etc. and population data in the potentially flooded area, and further predict the flood disaster Loss, provide decision support for river management, flood prevention and early warning.

(2) The accuracy of the model is related to the terrain data. One-dimensional constant flow flood evolution simulation calculation efficiency is high, and it is more suitable for river flood calculation, especially large rivers with large river widths.

(3) The simulation results show that among the villages along the river in the Hongqi River and Damalugou River Basin, Baili Village, Sanyang Village, Shiyang, Shiren Village, and Xiaguannmen Village were more severely affected by flooding.

(4) The combination of geographic information system technology and flood hydraulic model provides a scientifically feasible tool for flood prevention and mitigation research. The combination of the two can make the flood inundation analysis application of the river basin more convenient and scientific, and the flood supported by geographic information system technology Submergence simulation provides a good technical basis for the production of flood risk maps, and can provide a huge boost to flood disaster mitigation and flood control decision-making in small and medium-sized river basins.

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