

Research Progress of Flood Forecast in Medium and Small Basins

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Abstract

Flood is one of the frequent natural disasters in our country. With the development of society and economy, people put forward higher requirements for flood control construction. As an important non-engineering facility, the flood forecast and early warning system in small and medium watersheds makes full use of information technology to quickly collect and transmit rain and water information. This paper introduces the research process of medium and small watersheds, hydrological models and flood forecasting at home and abroad.

Keywords

Medium and Small Basins; Flood Forecast; Flood Early Warning.

1. Introduction

Floods are the most frequent and most damaging natural disasters in China. With the rapid economic and social development of our country and the more perfect social construction, it is necessary to improve the level of flood control. However, since the founding of the People's Republic of China, after the Huaihe River, Taihu Lake, and the Yangtze River in 1998 and other catastrophic floods, the great rivers have been vigorously managed, and the construction of embankments and rivers has been heavily invested, and dams and reservoirs are also scattered. In terms of non-engineering measures, radar rain measurement, automatic telemetry, flood control early warning and forecast system, and visual consultation system are very complete. However, small and medium-sized watersheds have not been systematically managed, and are facing a situation of "heavy rains and major disasters, and light rains and minor disasters". In fact, with 100km² as the unit of small watershed area, there are more than 50,000 medium and small rivers in my country. 85% of the total number of cities in the country along the rivers of small and medium-sized river basins. However, the flood control standards in small and medium-sized watersheds are generally low, most of which occur less than once in 10 years, posing a great threat to the safety of life and property of people in cities, towns, and villages along the river. In recent years, my country's climate has been abnormal, and extreme weather has occurred frequently, which has increased the pressure on flood control in small and medium-sized watersheds.

With the rapid development of the construction of small and medium-sized cities and towns, and at the same time, there are mainly cultivated land and fertile fields along the rivers in the small and medium-sized watersheds. The flood control problems in the small and medium-sized watersheds need to be solved urgently, especially some rivers that have not been

systematically treated and have serious environmental damage. These restrict local development.

2. Development History

2.1. Research Status of Small and Medium-sized Watersheds

A watershed is a catchment area surrounded by water dividers, including the area where surface water and groundwater naturally converge. Usually, a watershed refers to the surface catchment area. Small watersheds can be less than 1km^2 , and there are also small watersheds of more than 100km^2 . The spatial variability of small watersheds is large, and the current methods of dividing small watersheds are also different according to different needs. The Ministry of Water Resources stipulates that a small watershed is a watershed with an area of less than 50km^2 . For the governance of small and medium-sized watersheds in China, my country began to study the methods of small-watershed governance as early as the 1950s, and piloted and promoted the comprehensive governance of small watersheds. The management of small watersheds has roughly gone through four stages: the first stage, the small watershed governance model of contracted production to households in 1982, which promoted the development of small watersheds; the second stage of the watershed ecosystem governance model, which was integrated according to the geographical characteristics and economic attributes of the watershed Governance; the third stage of comprehensive management of information systems, with the development of GIS technology, remote sensing, communication, and computer science and technology, it provides technical support for the management of the watershed. , to provide information management functions for watershed governance; in the fourth stage, the watershed is managed as an energy circulation system, and the ecological and economic characteristics of the watershed should be integrated to jointly maintain the balance of its energy, material and information.

Foreign research on small watershed governance is relatively early. Since the 15th century, Austria began to manage small watersheds called barren stream governance. European countries have unified management of flash floods, mudslides and landslides. The United States established a special administration in 1933, which opened the situation of comprehensive management of small watersheds in the United States. From 1973 to 1982, Germany vigorously managed 250 small and medium watersheds.

Floods in small and medium-sized watersheds are characterized by strong seasonality, which may cause flooding in flood seasons, and rivers may stop flowing in dry seasons. In small watersheds, floods generally converge quickly, cause disasters quickly, and are destructive. The flood forecasting for medium and small watersheds mainly uses the relatively mature aggregated flood forecasting model to forecast in small watersheds, and also uses remote sensing technology, geographic information technology, high-resolution DEM, soil utilization type to conduct distributed flood forecasting research . However, there are large regional differences in small watersheds, and hydrological processes are greatly affected by water conservancy engineering facilities and human activities. Therefore, the model for a specific small watershed can only be adjusted or a model suitable for this watershed can be developed. Chen Yangbo et al. applied the Xin'anjiang model to flood forecasting in small watersheds, and proposed a method for parameter calibration of the Xin'anjiang model according to the characteristics of small watersheds such as short duration and fast confluence.

Xu Youpeng et al. focused on the intelligent extraction of parameters for the flood forecasting model in small and medium watersheds . Zhang Manli fully studied the advantages and disadvantages of the three water source Xin'anjiang model, unit line, rainfall-runoff correlation map and other models in small watershed forecasting, and concluded that the Xin'anjiang three water source model is suitable for the basin with many rainfall stations, uniform rainfall and

sufficient hydrological data. The correlation map method requires rich historical rainfall and runoff data or experienced forecasters; the Sherman unit line method is more suitable for medium and small watersheds, but it is necessary to pay attention to the impact of previous rainfall in flood forecasting. Chen Shengjia proposed a flood forecasting model suitable for arid and semi-arid medium and small watersheds. Yang Feng used high-resolution DEM image data and a distributed model to develop a flood forecasting system suitable for small and medium-sized watersheds without data. Cui Chunguang studied the impact of precipitation on flood forecasting during the forecast period, and concluded that the mesoscale model can improve the flood forecasting accuracy in flood season flood forecasting in medium and small watersheds. The application of traditional empirical correlogram method and lumped hydrological model in medium and small watersheds has been extensively studied and applied. Distributed research using DEM and experimental applications. At the same time, neural network, genetic algorithm, Markov chain method and fuzzy mathematics method have also been used in flood forecasting in small and medium watersheds.

2.2. Research Status of Hydrological Models at Home and Abroad

Flood forecasting is a non-engineering measure for flood control, and flood forecasting model is the guarantee of forecasting accuracy. Various methods have left model methods with relatively considerable prediction accuracy after being tested and screened in practice [1]. Horton proposed the theory of infiltration in his 1931 paper "The Role of Infiltration in the Hydrological Cycle" [2]. Sherman proposed the unit line method in the document "Using the Unit Line Method to Calculate Runoff from Rainfall" [3]. In 1935, McCarthy proposed the "Muskingen method" flood evolution method [4]. Snyder proposed integrated unit-line flood forecasting methods for basins lacking hydrological data, and these flood models are still in use today. The hydrological model takes the hydrological system as the object, and expresses the natural hydrological process systematically with mathematical programs, in order to predict the future hydrological phenomenon, which is an in-depth exploration of the hydrological laws. In the watershed range, the model can be divided into small watershed, medium watershed and large watershed hydrological model. In practice, models are often divided into lumped models and distributed models. Among them, the Xin'anjiang model is the only hydrological model that has a relatively large impact in our country's research. The rainfall-runoff model proposed by Mr. Zhao Renjun in 1973 was later upgraded to the Xin'anjiang model with three water sources, including underground runoff, soil intermediate flow and surface runoff. This model is suitable for wet areas. The Boughton model is generated on the basis of SWM. The SCS model is a hydrological model proposed by the United States for flood forecasting in small and medium watersheds. Tank model (water tank model) is to simulate the process of rainfall and runoff in the watershed with the water entering and leaving the water tank [5,6]. With the development of computer science and technology, intelligent models such as artificial neural networks and legacy algorithms have begun to be used in flood forecasting. Professor Xia Jun applied the grey artificial neural network model to flood forecasting.

The TOPMODEL model is a semi-distributed model, a transition model from lumped to distributed [7]. It mainly considers the topographic features of the watershed and takes the slope value as a parameter. The model is mainly used in areas with large fluctuations in the underlying surface [8]. Distributed model is the development trend of hydrological model, and it is also the road to more accurate hydrological model. The distributed model takes into account the spatial variability of rainfall and underlying surface, and can truly reflect the impact of spatial rainfall and underlying surface changes on the flood process. Rather than using average rainfall or uniform influencing factor parameters across the basin. A distributed hydrological model needs to consider topography, soil type maps, vegetation distribution maps, land use type maps, and as many rainfall station data as possible. The representative models in

the distributed model are the SHE model and the SWAT model. The research on the distributed model depends on the development of computer technology, geographic information technology, remote sensing technology and radar rain measurement. For the various hydrological information of the whole basin, it is unrealistic to collect a large amount of manual work, and the workload is large and the efficiency is low. Remote sensing technology can indeed solve these problems. Remote sensing can provide high-resolution topographic data and ground cover vegetation data. Radar rainfall measurement makes it possible to obtain rainfall in a large area of watershed. In some places, dense rainfall stations have timely communication equipment. It also provides conditions for large-scale collection of rainfall. At the same time, the effective management of spatial terrain data, vegetation, soil data, hydrological data and attribute data of some engineering facilities is inseparable from geographic information technology with powerful analysis functions. At the same time, the visualization advantages of geographic information can not only make hydrological information clear on the map, but also generate thematic maps, analyze the rain and disaster conditions, and provide intuitive decision-making for flood control.

The domestic distributed model research started relatively late, and there are certain researches in many aspects. For example, Guo Shenglian studied the distributed hydrological model based on DEM. It is foreseeable that the distributed hydrological model is the future development trend, and the distributed hydrological model fully considers the temporal and spatial variability of rainfall, and the impact of natural and human activities on hydrological processes. In addition, the previous lumped hydrological models were calculated from the fall of rainfall, and the observation data were often limited to hydrology and meteorology, and the research on comprehensive disciplines such as geography, soil, and environment was slightly insufficient, which caused floods. The forecasting accuracy of forecast is not up to people's ideals. On the other hand, due to the complexity of the hydrological mechanism and the limitations of existing observation methods, many data and methods are generalized and cannot be obtained accurately. It is understood that the more accurate application of the hydrological mechanism, the distributed hydrological model will surely move from the laboratory to the practical application, and be used in a wide range. But at present, there are still many difficulties in the application of distributed models. Most of the current distributed applications use lumped models in divided sub-basins or grid watersheds, and then superimpose and summarize. It is not very mature to fully integrate the strong graphic display ability and spatial analysis ability of GIS and the high-precision data of the underlying surface reflected by remote sensing images into the hydrological process, resulting in that the distributed model is not widely used in reality. Most of the lumped hydrological models have many parameters, and many parameters are not necessarily accurate, because the data itself has errors, and the theoretical systematic errors of the models will lead to large deviations. On the contrary, some simple models have higher prediction accuracy. The distributed model has many advantages, but the research on many problems is not ideal. Although it is now a research hotspot of scholars, it is still dominated by mature lumped models in practical applications.

2.3. Current Status of Research on Flood Forecasting at Home and Abroad

Flood forecasting is a part of hydrological forecasting. It is an applied discipline that integrates various hydrological information, meteorological information, and underlying surface information, and forecasts future floods and processes such as runoff and water level according to hydrological laws. The flood forecasting system takes the hydrological model as the mathematical core, uses computer technology, and combines communication technology to collect, process and analyze water and rain information, other spatial information and other attribute information. forecast information system. A reliable, robust and efficient flood forecasting system can provide scientific support for flood control command.

The development of flood forecasting system abroad is relatively early and the system is relatively mature. Generally, it is divided into three stages according to its development stage: online forecasting stage, real-time correction forecasting stage, and interactive forecasting stage. Online forecasting is to collect and process information related to flood forecasting, such as water regime, rain regime, and weather, for flood forecasting, giving full play to the rapid processing capability of computers. The second stage of real-time correction is to introduce modern control theory to control and correct each stage of forecasting. The third stage is the one that is going through now, which integrates computer processing and graphic display capabilities, expert systems and forecasting experience. That is to say, it does not completely rely on the one-time operation of the computer and the model, and fully allows the forecasters to intervene in the forecasting process, reducing systematic and uncertain errors, and improving the forecasting accuracy. With the development of GIS and RS technologies, the powerful data acquisition, processing, spatial analysis and graphic display capabilities of GIS and the large-scale high-resolution spatial data provided by RS have provided strong support for the development of distributed models and promoted the development of distributed models. developed an interactive forecast for flood forecasting. NWSRFS is a general flood forecasting system developed in the United States to meet the requirements of all watersheds. However, the 1-4 version models are not applicable to the whole country, until the fifth version contains various models, users can freely choose the model and its parameters, and can add new models independently. An Jiang model. The fifth version was developed from 1979-1984, and the model was first used in the Tulsa River in 1985, and the system was later installed in rivers throughout the United States. The development of interactive hydrological models is actually mainly due to the development of computers. In 1988, NWSRFS developed a graphical display interface, and interactive forecasting was really born at this time. The development of interactive forecasting is determined by the structure of the hydrological model and the process of the hydrological cycle. First, the structured hydrological process equation cannot accurately express the real hydrological process. Second, the calibration of parameters is based on historical data. Even if the simulation matches well, it does not mean that it can accurately predict the future. In the end, it is determined by the hydrological model. The forecast model usually divides the watershed, and the evolution of the river channel is also estimated from the upstream to the downstream. In this way, the error of the sub-basin or the upstream will inevitably be passed down, and finally lead to a larger error. This is the inherent characteristic of hydrological forecasting, and it is also the inevitability of forecasting to interactive development. Another feature of interaction is that the graphical interface provides more intuitive and efficient interactive operations, and the forecast results can also be output intuitively. The forecasting system in the United States is relatively advanced, which is closely related to the US's technological dominance. The United States highlights the temporal and spatial distribution of rainfall in sudden flood forecasting, not only limited to point rainfall [9]. In the aspect of radar rain measurement, the forecast of rainfall intensity in the rainfall range is expanded, and the comparison with the station is strengthened. The FFWRS system in EU countries has many applications, that is, the system integrating forecasting, early warning and response. The system is based on a conceptual model and is derived from the disaster warning system. The system consists of detection, forecasting, early warning and disaster response. Any error in any of these links will cause subsequent results to be scrapped. The system can be automated in all aspects and has high prediction accuracy.

The development of flood forecasting system in my country is relatively late compared to foreign countries. Since 1983, foreign flood forecasting systems have been introduced, which are complete systems imported from American companies, and the effect is not good . In 1986, the Long Committee developed a set of real-time forecasting systems applied in Yichang and Hankou, and Ge Shouxi and others developed an interactive forecasting system with reference

to the forecasting system of the United States, which promoted the development of the forecasting system in my country. In 1999, the Water Conservancy Information Center of the Ministry of Water Resources and other water conservancy units developed a national water and rain and flood forecasting system that includes multiple model libraries and has certain interactive capabilities. In 2001, the National Flood Forecasting System developed by the Hydrology Bureau realized the national real-time flood forecasting based on the national water regime data. In 2002, Guo Shenglian et al. realized interactive forecasting in the national reservoir flood control dispatching system, which realized the interactive operation guided by graphs.

After so many years of development in China, the hydrological model and flood forecasting system have made great progress, which has made great contributions to the development of our country's flood defense. In particular, the development of GIS and RS will provide technical support for the informatization and precision of flood forecasting systems. Science and technology are the key, and data is the basis for hydrological analysis and flood forecasting. These are inseparable from radar, remote sensing, and telemetry systems to provide accurate data, as well as convenient communication systems. With the rapid development of social economy and the improvement of flood control requirements, the performance of the interactive expert forecast system also needs to be improved. These need to be deeply integrated with geographic information system technology to give full play to the powerful organizational attribute data and spatial data of GIS. capabilities and advantages in graphical display and 3D visualization simulation. With the closer integration of GIS, RS and hydrological models, the further improvement of the software level, the rapid development of communication technology, big data, and distributed computing, the flood forecasting system will develop rapidly.

3. Summary

The main reasons for the frequent occurrence of flood disasters in small and medium-sized watersheds are the weak flood control infrastructure of river channels, the encroachment of river channels, and the generally low quality of embankment works. Unable to withstand the baptism of floods, landslides and dyke bursts occur from time to time, causing great pressure on flood control. In view of the situation of small and medium-sized watersheds, the construction of engineering facilities in small and medium-sized watersheds has been strengthened in recent years, but the non-engineering facilities such as forecasting and early warning in small and medium-sized watersheds are lagging behind. By analyzing the flood control characteristics of small and medium-sized watersheds, studying the forecasting and early warning methods suitable for small and medium-sized watersheds, and establishing a flood forecasting and early-warning system for small and medium-sized watersheds based on GIS technology, it can effectively enhance the ability of small and medium-sized watersheds to prevent floods and disasters.

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