

Managing Floods: An Overview of Flood Routing Techniques and Their Challenges

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Abstract

This article provides an overview of flood routing techniques, which are a critical tool for managing floods and protecting human life and property. Flood routing techniques involve the use of mathematical models and data to predict the timing and magnitude of floods, and to manage the impact of floods on the surrounding area. The article discusses the different types of flood routing techniques, including hydrological routing, hydraulic routing, and integrated routing, and their applications in flood management. Additionally, the article highlights the challenges that flood routing techniques face, such as limited data availability, uncertainty, changing climate, and limited resources. Overall, this article emphasizes the importance of effective flood management and the need to continue to develop and refine flood routing techniques based on new data and technologies.

Introduction

Floods are among the most destructive natural disasters that can occur in any location worldwide. Flood routing techniques are used to predict the flow of water in a channel during a flood. These techniques can be used to estimate the height and the speed of the water flow in a river or stream. This information can be used to help plan for the possible impact of a flood, to manage the floodwaters and to limit the damage to property and people.

Flood routing techniques involve the use of mathematical models that are designed to simulate the flow of water in a river or stream. There are several different types of flood routing techniques that can be used, including hydrological models, hydraulic models, and empirical models. In this article, we will discuss the different types of flood routing techniques and how they are used in flood prediction and management.

Types of Flood Routing Techniques

Hydrological models

Hydrological models are mathematical models that are designed to simulate the water cycle in a river basin. These models take into account various factors such as rainfall, evapotranspiration, soil moisture, and land use to predict the amount of water that will flow into a river or stream during a flood. Hydrological models can be used to estimate the magnitude and timing of floods in a particular area. There are two types of hydrological models that can be used in flood routing:

a. *Conceptual models:*

Conceptual models are simple models that use a set of equations to simulate the hydrological cycle in a river basin. These models are easy to use, but they are less accurate than other types of hydrological models.

b. *Physically-based models:*

Physically-based models are more complex than conceptual models, and they use detailed equations to simulate the hydrological cycle in a river basin. These models are more accurate than conceptual models, but they require more data and resources to use.

Hydraulic models

Hydraulic models are mathematical models that are designed to simulate the flow of water in a river or stream. These models take into account various factors such as the shape of the riverbed, the roughness of the riverbed, and the gradient of the riverbed to predict the height and speed of the water flow during a flood.

There are two types of hydraulic models that can be used in flood routing:

a. *1D models:* One-dimensional (1D) models are used to simulate the flow of water in a river or stream in one direction only. These models are easy to use and require less data and resources than other types of hydraulic models.

b. *2D models:* Two-dimensional (2D) models are used to simulate the flow of water in a river or stream in two directions. These models are more complex than 1D models, and they require more data and resources to use. However, they are more accurate than 1D models because they take into account the shape of the riverbed in two directions.

Empirical models

Empirical models are mathematical models that are based on observed data rather than on theoretical equations. These models are used to estimate the flow of water in a river or stream during a flood based on past flood events.

Empirical models are simple to use, but they are less accurate than hydrological or hydraulic models because they do not take into account the physical properties of the river or stream. However, they can be useful in areas where there is limited data available, or where other types of models are not suitable.

Modelling Software

There are various software options for different types of models. Here are some examples:

Hydrological models:

HEC-HMS: This software is developed by the US Army Corps of Engineers, and it can be used to perform hydrological modelling, including watershed analysis, floodplain mapping, and flood routing.

MIKE SHE: This is a hydrological model developed by DHI, which can be used to simulate the water balance of a catchment, including groundwater and surface water interactions.

SWMM: The Storm Water Management Model is an open-source hydrological model developed by the US EPA, which can be used to simulate the quality and quantity of stormwater runoff.

Hydraulic models:

HEC-RAS: This software is developed by the US Army Corps of Engineers, and it can be used to perform hydraulic modelling, including river and floodplain hydraulics, bridge and culvert hydraulics, and sediment transport.

MIKE 21: This is a hydraulic model developed by DHI, which can be used to simulate waves, currents, and sediment transport in coastal and marine environments.

LISFLOOD-FP: This is a 2D flood inundation model developed by the University of Bristol, which can be used to simulate flood events and produce flood inundation maps.

Empirical models:

USGS StreamStats: This is a web-based application developed by the US Geological Survey, which can be used to estimate the flow characteristics of a stream or river based on digital elevation data and other spatial data.

Flood Frequency Analysis (FFA): This is a statistical method used to estimate flood frequency and magnitude based on historical flood data. The FFA can be performed using statistical software such as R, SAS, or SPSS.

Flood Routing Techniques

Flood routing techniques are used to predict the flow of water in a river or stream during a flood. There are several different flood routing techniques that can be used, including:

Muskingum-Cunge method

The Muskingum-Cunge method is a hydrological model that is used to predict the flow of water in a river or stream during a flood. This method is based on the principle of conservation of mass and energy, and it takes into account the storage and routing of water in the river channel.

The Muskingum-Cunge method uses a set of equations to predict the water flow in a river or stream. These equations take into account the inflow of water into the river or stream, the outflow of water from the river or stream, and the storage of water in the river or stream. The method is used to estimate the water flow at a particular point in the river or stream, as well as the timing and magnitude of the peak flow.

Kinematic wave method

The kinematic wave method is a hydraulic model that is used to predict the flow of water in a river or stream during a flood. This method is based on the principle of conservation of mass and momentum, and it takes into account the slope and roughness of the riverbed.

The kinematic wave method uses a set of equations to predict the water flow in a river or stream. These equations take into account the slope and roughness of the riverbed, as well as the inflow and outflow of water. The method is used to estimate the height and speed of the water flow at a particular point in the river or stream.

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Hydrodynamic models

Hydrodynamic models are hydraulic models that are used to predict the flow of water in a river or stream during a flood. These models take into account the complex physical properties of the river or stream, such as turbulence, eddies, and sediment transport.

Hydrodynamic models use a set of equations to predict the water flow in a river or stream. These equations take into account the slope and roughness of the riverbed, as well as the inflow and outflow of water. The models are used to estimate the height and speed of the water flow at a particular point in the river or stream, as well as the timing and magnitude of the peak flow.

Applications of Flood Routing Techniques

Flood routing techniques are used in a variety of applications, including flood prediction, flood management, and flood mitigation. These techniques can be used to estimate the height and speed of the water flow in a river or stream during a flood, as well as the timing and magnitude of the peak flow.

Flood prediction

Flood routing techniques are used to predict the occurrence of floods in a particular area. These techniques can be used to estimate the timing and magnitude of a flood, as well as the potential impact of the flood on the surrounding area. Flood prediction can help emergency managers to prepare for a flood, to evacuate people from areas that are at risk, and to mobilize resources to respond to the flood.

Flood management

Flood routing techniques are used to manage the impact of floods on the surrounding area. These techniques can be used to control the flow of water in a river or stream, to protect infrastructure and property from flood damage, and to manage the water supply during a flood. Flood management can include the construction of levees and flood walls, the installation of flood control structures such as dams and weirs, and the development of flood warning systems.

Flood mitigation

Flood routing techniques can also be used to mitigate the impact of floods on the surrounding area. This can include the development of floodplain management strategies, the creation of natural flood protection measures such as wetlands and floodplain forests, and the restoration of rivers and streams to their natural state. Flood mitigation can help to reduce the risk of flood damage, to protect human life and property, and to preserve natural ecosystems.

Challenges in Flood Routing Techniques

Despite the many benefits of flood routing techniques, there are several challenges that must be addressed in order to effectively manage floods. These challenges include:

Limited data availability: Flood routing techniques rely heavily on data, including hydrological data, hydraulic data, and meteorological data. However, in many areas, data is limited or not available, making it difficult to accurately predict the timing and magnitude of floods.

Uncertainty: Flood routing techniques involve a high degree of uncertainty, due to the complexity of the natural systems involved. This uncertainty can make it difficult to accurately predict the impact of a flood, and can result in errors in flood predictions and management.

Changing climate: Climate change is expected to have a significant impact on the frequency and intensity of floods in many areas. This can make it difficult to develop effective flood management strategies, as historical data may no longer accurately predict the timing and magnitude of floods.

Limited resources: Effective flood management requires significant resources, including funding, personnel, and equipment. In many areas, these resources are limited, making it difficult to implement effective flood management strategies.

Conclusion

Flood routing techniques are a critical tool for managing floods and protecting human life and property. These techniques can be used to predict the timing and magnitude of floods, to manage the impact of floods on the surrounding area, and to mitigate the risk of flood damage. However, these techniques also face several challenges, including limited data availability, uncertainty, changing climate, and limited resources. To effectively manage floods, it is important to address these challenges and to continue to develop and refine flood routing techniques based on new data and technologies.