Exploring the Capabilities and Limitations of the MIKE SHE Model in Hydrological Modelling

C. P. Kumar, Former Scientist 'G', National Institute of Hydrology, Roorkee - 247667, India

Abstract

The MIKE SHE model is a widely used hydrological model that simulates the movement of water through the hydrological system, from precipitation to surface runoff, infiltration, evapotranspiration, and groundwater flow. It is a spatially-distributed model that takes into account variations in soil properties, vegetation cover, topography, and climate across the landscape. The model has a wide range of applications in flood forecasting, water resources management, land-use planning, and environmental modelling. However, it also has limitations and challenges, including data requirements, model complexity, parameter uncertainty, and model validation. This article provides an overview of the MIKE SHE, its components, and its applications, as well as a discussion of its limitations and challenges.

Introduction

The MIKE SHE model is a well-known and widely used integrated hydrological model developed by the Danish Hydraulic Institute (DHI). It is a three-dimensional, spatially-distributed model that simulates water movement through the soil, vegetation, and the atmosphere. MIKE SHE was first developed in the 1990s and has since undergone several revisions and updates, becoming one of the most sophisticated and widely used hydrological models in the world.

The MIKE SHE model is used in a variety of applications, including flood forecasting, land-use planning, and water resources management. It has been used to model water flow and quality in a variety of settings, including urban and rural environments, as well as in wetlands and other natural systems.

This article provides an overview of the MIKE SHE, its main features, and its applications. We will explore the basic principles of the model, how it works, and how it is used to simulate hydrological processes.

Basic Principles of MIKE SHE

The MIKE SHE model is based on the principle of mass balance, which means that the total amount of water in the system must be conserved. The model simulates the movement of water through different compartments of the hydrological system, including the atmosphere, the soil, and the vegetation.

The model is designed to simulate a wide range of hydrological processes, including surface runoff, infiltration, evapotranspiration, groundwater flow, and subsurface flow. It uses a complex set of equations to simulate the interactions between these processes and the various compartments of the hydrological system.

The MIKE SHE model is a spatially-distributed model, meaning that it simulates water movement and hydrological processes across a three-dimensional grid. This allows the model to take into account variations in soil properties, vegetation cover, topography, and climate across the landscape.

How the MIKE SHE works

The MIKE SHE model is made up of several components, each of which simulates a different aspect of the hydrological system. These components include the soil water balance component, the surface water balance component, the groundwater flow component, and the surface-subsurface interaction component.

Soil water balance component

The soil water balance component of the MIKE SHE simulates the movement of water through the soil. It takes into account the soil properties, including soil texture, porosity, and hydraulic conductivity, as well as the soil moisture content.

The model calculates the soil water balance by considering the inflows and outflows of water in the soil. Inflows include precipitation, irrigation, and groundwater recharge, while outflows include evapotranspiration, surface runoff, and subsurface flow.

The soil water balance component also takes into account the effect of vegetation on soil moisture content. Vegetation can significantly affect the amount of water in the soil, as plants take up water through their roots and release it through transpiration.

Surface water balance component

The surface water balance component of the MIKE SHE simulates the movement of water across the land surface. It takes into account the topography, soil properties, and vegetation cover, as well as the amount and intensity of rainfall.

The surface water balance component calculates the surface runoff by considering the amount of rainfall that exceeds the soil infiltration capacity. The model also takes into account the effect of vegetation cover on surface runoff, as well as the effect of land use and land cover on surface water flow.

Groundwater flow component

The groundwater flow component of the MIKE SHE simulates the movement of water through the subsurface. It takes into account the geology, soil properties, and groundwater recharge and discharge.

The model calculates the groundwater flow by considering the inflows and outflows of water in the subsurface. Inflows include groundwater recharge, while outflows include groundwater discharge.

Surface-subsurface interaction component

The surface-subsurface interaction component of the MIKE SHE simulates the interaction between the surface water and groundwater systems. It takes into account the hydraulic properties of the soil and the subsurface, as well as the surface water and groundwater flow rates.

The model calculates the surface-subsurface interactions by considering the hydraulic gradient between the surface and subsurface systems. It also takes into account the effect of groundwater on the soil moisture content and the effect of surface water on groundwater recharge.

Overall, the MIKE SHE integrates these different components to simulate the movement of water through the hydrological system, from precipitation to surface runoff, infiltration, evapotranspiration, and groundwater flow.

Applications of the MIKE SHE

The MIKE SHE has a wide range of applications in hydrology, water resources management, and environmental modelling. Some of its main applications include:

Flood forecasting: The MIKE SHE model is used to simulate the flow of water in rivers and other waterways, which can be used to predict and mitigate flooding events.

Water resources management: The MIKE SHE model is used to simulate water availability and usage in a variety of settings, from urban water supplies to agricultural irrigation systems.

Land-use planning: The MIKE SHE model is used to simulate the effects of land-use changes, such as deforestation or urbanization, on the hydrological system.

Environmental modelling: The MIKE SHE model is used to simulate the movement of pollutants through the hydrological system, including nutrients, sediment, and other contaminants.

In addition to these applications, the MIKE SHE model is also used in research to better understand the processes that govern the hydrological system, including the interactions between surface water and groundwater, the effects of climate change on hydrology, and the role of vegetation in regulating the water balance.

Limitations and Challenges of MIKE SHE

Like all models, the MIKE SHE has some limitations and challenges that must be taken into account when interpreting its results. Some of the main limitations of the model include:

Data requirements: The MIKE SHE model requires a significant amount of data to be inputted, including soil properties, vegetation cover, topography, and climate data. The quality and availability of this data can affect the accuracy of the model's results.

Model complexity: The MIKE SHE model is a complex and computationally intensive model, which can make it difficult to run and interpret. It also requires significant expertise to use and configure properly.

Parameter uncertainty: The MIKE SHE includes many parameters that must be calibrated to fit the specific characteristics of the study area. The uncertainty in these parameters can affect the accuracy of the model's results.

Model validation: The MIKE SHE model must be validated against observed data to ensure that its results are accurate. This can be challenging, as there may be discrepancies between the model's results and observed data due to measurement errors or other factors.

Conclusion

The MIKE SHE model is a sophisticated and widely used hydrological model that simulates the movement of water through the hydrological system. It is a spatially-distributed model that takes into account variations in soil properties, vegetation cover, topography, and climate across the landscape.

The MIKE SHE has a wide range of applications, including flood forecasting, water resources management, land-use planning, and environmental modelling. However, the model also has some limitations and challenges, including data requirements, model complexity, parameter uncertainty, and model validation.

Overall, the MIKE SHE model is an important tool for understanding and managing the hydrological system, and it is likely to continue to be used in a wide range of applications in the future.