NEW TREND AND APPLICATION OF RUNOFF ANALYSIS

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Abstract:

Water-related disasters such as floods and droughts are increasing in the world and their scale of damage and impact is becoming increasingly serious. This may be caused by factors like climate change in global scale, rapid population growth, the high concentration of population and property in urban areas, etc. In Japan, flood risk is seriously high because of its special meteorological and geophysical conditions. Typhoons and Bay-u fronts bring heavy rainfall to Japan. Rivers are characterized by rapid runoff because of steep slopes of Japanese mountains. In addition, large fraction of the population and property are concentrated in floodplains which have the large potential of inundation.

In order to arrive at good flood simulation results, it is important not only to develop physically-based runoff models but also to clarify a runoff mechanism in a basin. A large number of refined physical models or theories were proposed to simulate runoff in real watersheds during the last several decades, and offered us a wealth of useful information about the mechanism of water flow in a catchment and its contribution to the runoff.

Two major developments transformed hydrology by making it more physical than empirical science. The first was the availability of increasingly-powerful computers which enabled the development of much more complex runoff models. The second was the recent developments in the remote sensing techniques. These technological developments have kindled a new interest in describing and modeling hydrological processes considering spatially distributed hydrological characteristics by using a distributed runoff model. Especially, over the last 10 years, remote sensing has emerged as a potential solution to many hydrological problems, and it holds out the possibility of a true distribution modeling capability in hydraulics. Pixel sizes for remotely sensed data are often the same as distributed model element scales.

We have developed a framework for simulation of flood flow based on meteorological and geophysical information. This is an integrated approach which covers part of water cycle from rainfall to flood inundation calculation. This method can be adopted for diverse scenarios including urban areas and mountainous terrains. In particular, the method is very promising for forecasting flood disasters in small basins and developing countries where the past hydrological data is insufficient. We continue developing our model and intend to eventually devise a method for utilizing the advanced remote sensing techniques in any region where the parameters concerning soil property, topographic characteristic, and land-use are available.

We have a Doppler radar for meteorological observations, whose detection range is 256km, and it covers all of the Kanto plain. Radar information is used: 1) to analyze the rainfall characteristics of growth and decay; 2) input rainfall data for runoff calculation considering the temporal and spatial distribution of rainfall; and 3) predict rainfall. There are two methods to predict rainfall using Doppler radar information. One is to predict rainfall by visual Doppler radar images. The other method is to predict rainfall by using physical models together with Doppler radar information.

The land use is automatically classified by using IKONOS satellite images, and the information is provided as the ground surface data regarding urban areas. Geographic characteristics like river networks and basin boundaries in mountainous terrains are extracted from GIS data including Digital Elevation Models. For runoff analysis in urban areas, a model consisting of surface and pipe-flow components is being used. In mountainous basins, a lumped model based on the Kinematic wave scheme is proposed. From the relationship between unsaturated flow theory and Kinematic wave equation, the parameters of this model are determined based on topographic and geographic characteristics. This is extremely important for flood prediction in ungauged basins where hydrologic data is insufficient. Also this model can demonstrate surface flow, subsurface flow, vertical infiltration flow and ground water flow, depending on differences in soil properties. At the same time, water quality hydrographs, which illustrate change in the concentration of various substances in river water during a rainfall event, are simulated by using a new theory based on the law of conservation of mass. With regarding to flood routing in rivers, one-dimensional unsteady flow calculation is carried out in a large-scale channel networks. In small mountainous basins where the effect of river channels is small, a lumped model using Kinematic wave theory is used. It is not important to carry out the unsteady flow model in small mountainous basins in case their spatially scale is in the order of 100km^2. For the flood inundation simulation, the YASUDA/YAMADA (C.E.R.I. of Hokkaido, Chuo University) model is used. This model uses topography-fitting grids in order to calculate rapidly with good accuracy. In this flood prediction system, a new method of flood control by dam gate operation based on runoff characteristics of a basin will also be presented. This method is based on the idea that there is no risk to reduce reservoir level if the amount of anticipatory release equal to the amount of inflow which flows into a dam certainly from the rainfall that has already fallen.