NUMERICAL PREDICTION EXPERIMENT OF A WATERSHED MODELING SYSTEM

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1. INTRODUCTION

This is a numerical prediction experiment of a watershed modeling system. A physically-based watershed modeling system, WASH123D, is applied to a real watershed for flooding simulation during a storm event.

The watershed modeling system, WASH123D, simulates coupled water flow and transport in one-dimensional channel network, two-dimensional overland, and three-dimensional subsurface porous media. The governing equations for surface flow are based on the shallow water equations or their approximate forms (diffusion wave and kinematic wave models). The modified Richards equation is applied for subsurface flow. Developed for generic application, hydraulic structures, such as weirs/gates, culverts, pumping, retention ponds, and levees/dikes, are incorporated into the model.

In the surface flow components, the numerical solution for both one-dimensional (channels) and two-dimensional (overland) full shallow water equations is based on the Lagrangian-Eulerian finite element method. The method of characteristics (MOC) is applied for the advection terms. The Galerkin finite element method is used for the turbulent diffusion terms. Parabolic type governing equations of the diffusion wave model are solved by the Galerkin finite element method. The pure advection kinematic wave models are solved by Lagrangian method. In the subsurface flow component, Galerkin finite element method is used to solve the modified Richards equation. Internal coupling among overland and channel flow, overland and subsurface flow, and channel and subsurface flow is also considered.

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2. NUMERICAL EXPERIMENTS AND RESULTS

The model was applied to the South Fork Broad (SFB) River watershed in Georgia (Figure 1). The surface area of the watershed is about 453 square kilometers. The watershed was divided into 5567 triangular elements with 10,943 nodes.

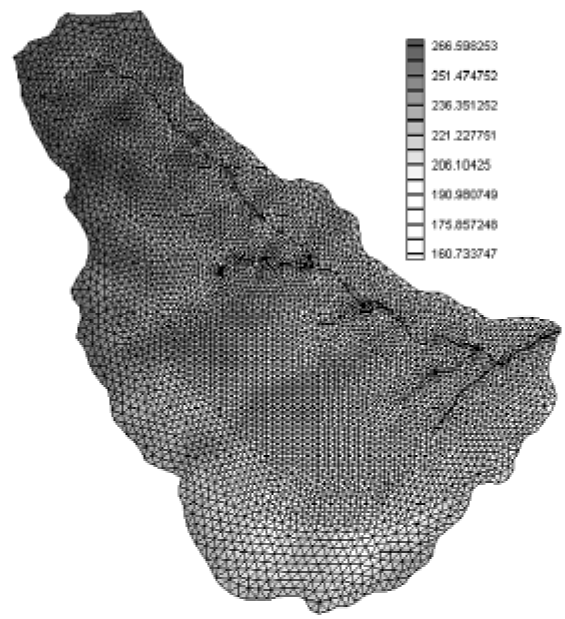

Figure 1. The topography and computational grids of the SFB watershed.

The rainfall prediction is provided by a high resolution mesoscale model, Penn State/NCAR MM5 (Version 3.4). The storm event is chosen during the extra-tropical transitional period (3-5 Sept 1998) of Hurricane Earl (1998). The initial and boundary conditions of MM5 are prepared from the NCEP Global Analyses on 2.5 degree grids with 12 hour intervals. Four nesting domains are used in the MM5 forecast. The grid size on Mercator projection are 135, 45, 15, and 5~km, respectively. The 5~km domain rainfall forecasts at 10-minutes intervals are used in the watershed modeling. Figure 2 is the 24-hour accumulated rainfall forecast for the SFB watershed.

In this study, only surface runoff is considered and the diffusion wave approximation is used. A simple infiltration model is used to compute the infiltration loss from rainfall. A Manning's roughness of 0.015 is used.

The forecasted rainfall data provides spatially and temporally varied rainfall time series for each triangular element and are used for flood runoff modeling. Since the rainfall rate during the first 20 hours is less than the assumed saturated soil conductivity, 5.0E-7 m/s, it is assumed that all rainfall during this period was absorbed into soil. Then a three-hour simulation during the heavy rainfall period with a rainfall rate greater than 1.0E-6 m/s is conducted. Figure 3 is the water depth distribution in the watershed at the 2.667 hours during the three-hour simulation. At this time, most rainfall falling on the land surface became runoff and accumulated in the river valley.

3. CONCULSIONS

A physically-based watershed model (WASH123D) is applied to the South Fork Broad watershed for a storm flooding simulation. Preliminary results indicate that flooding processes and flooded area are reasonably simulated with rainfall forecast from a mesoscale atmospheric model, Penn State/NCAR MM5.

REFERENCES

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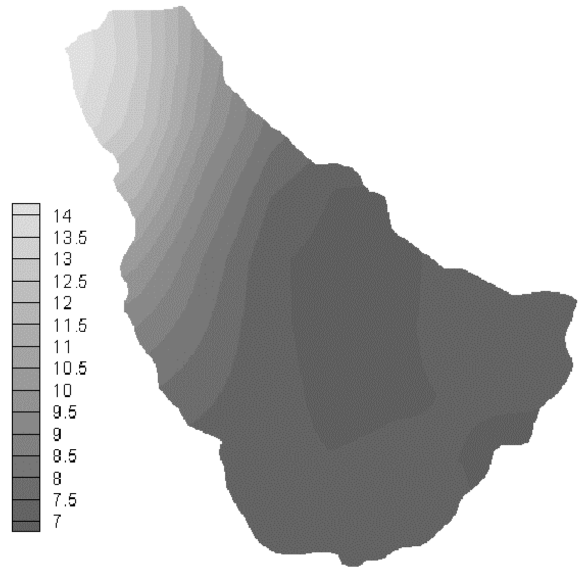

Figure 2. The 24 hour accumulated rainfall (cm) forecast of MM5 from 12UTC 03 October 1998 to 12UTC 04 October 1998.

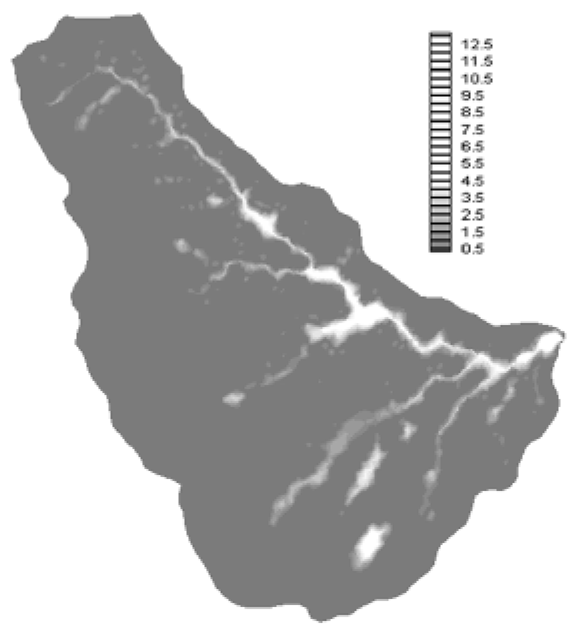

Figure 3. The simulated water depth at 2.67 hours.