第 II 部門 Effects of Geomorphologic Factors on Flood Generation and Propagation

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1 INTRODUCTION

In Japan and other South East Asian countries, floods constitute a major natural hazard due to unique morphological and hydrometeorological conditions. Most basins in these countries have rivers flowing through steep narrow gorges on highlands where floods normally originate during typhoon events. In This paper a model which considers effects of geomorphologic factors in flood simulation is introduced.

2 MODEL STRUCTURE

This study uses SOWM-YRB model. The model can link different types of process models and operation rules to describe hydrological response of a watershed [1]. The configuration adopted for flood simulation emphasizing on the effects of geomorphologic factors is briefly introduced below.

2.1 Infiltration component

The infiltration component is based on the Green and Ampt infiltration model. Gross rainfall at ground surface is converted into time variable runoff depth depending on soil and surface conditions. The governing equations of this component as appear in Kimaro[1] are:

$$t'_p = \frac{1}{K_s}\left(F_p - S_f M \ln\left(1 + \frac{F_p}{MS_f}\right)\right) \quad (1)$$

$$f = K_s + \frac{K_s S_f M}{F_p} \quad for \quad t > t_p \quad (2)$$

$$M = \theta_s - \theta_i \quad (3)$$

$$P_g \Delta t = \Delta F + \Delta S + O \quad 0 \le S \le D \quad (4)$$

where F is the infiltration volume, tp' is time required to infiltrate volume Fp, θ_s is soil porosity, θ_i is initial soil moisture, S_f is the effective suction head, K_s is saturated hydraulic conductivity and f is the infiltration rate. Others are D surface storage capacity, S variable for water stored in D, runoff volume RO and M initial soil moisture deficit. Important parameters in this model as regards the current study are K_s, M and D. These parameters control the volume of generated runoff depth depending on the initial soil moisture, soil type and surface conditions. The parameter for surface storage D is related to landuse in such a way that it allows runoff to form quickly in well drained surfaces and delays runoff from rough and rugged surfaces. Lower values of D indicate well drained surfaces such as urban areas while higher values indicate poorly drained areas. This formulation is mainly expected to enable the model capture the effects of soil types land use on flood volumes.

2.2 Routing scheme

The model uses the DEM data of Geographic Survey Institute (GSI) for delineating the watershed and to provide a flow direction map used for integrating runoff spatially. Topography of the watershed is represented by both flow direction and slopes as defined at arbitrary spatial resolution by aggregating the original 50m DEM grids into coarser resolutions.(Kimaro [1]). The integration of flow downstream is performed by kinematic wave routing over grids intended to capture the effect of land use on the movement of runoff downstream.

3 APPLICATION OF THE MODEL

The proposed model was applied in the Yasu River basin. Remotely sensed Landuse data obtained from GSI was used for extracting spatially distributed roughness values. In studying the effects of land use changes on flood runoff a comparison is made between runoff generated using 1976 and 1997 land use data for the same rainfall event and initial conditions. A digital elevation model of the basin at 50m resolution was used to derive the flow network which compares fairly close with the digitized channels. The model is based on common GIS database and can be implemented anywhere in Japan. Distributed rainfall input was generated from ground measurements by ordinary Kriging.

4 RESULTS AND DISCUSSION

The model is configured to output hydrographs and runoff maps for any location in the basin. All distributed inputs and results are in raster format compatible to common GIS software. Runoff maps and hydrographs are used to study the effects of geomorphologic factors on flood generation and propagation.

4.1 Changes in flood peaks and travel time

Fig. 1 shows the hydrograph at Yasu gauging station during flood event on 30th September 1994.

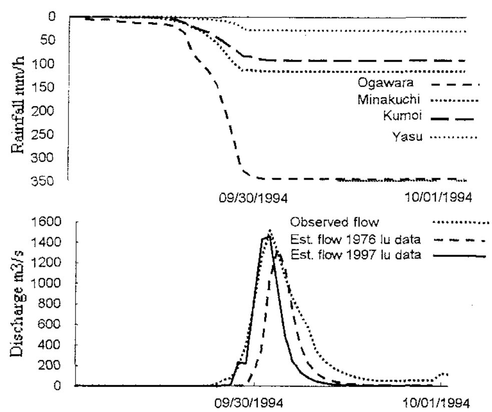

Figure 1. Effects of landuse changes in the Yasu River basin.

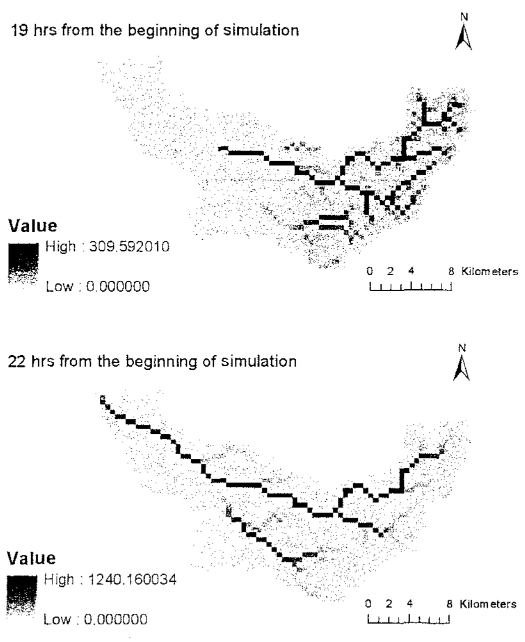

Figure 2. The generation of flood runoff during a typhoon event in the Yasu River basin in 1994.

The trial and error tuning of the initial soil moisture (parameter M eq.3) was necessary to match the observed and estimated peak flows. The infiltration parameters for this event are K_s =0.0034 and M=0.242. Similar parameters were used in simulating the same event with 1976 land use data. Results show simulated hydrograph deviates from the estimated hydrograph produced with 1997 land use data. The timing of the flood peak at Yasu is delayed and the magnitude of the peak flow is reduced.

4.2 Spatial Integration of flood runoff.

The generation of flood and its propagation downstream is show in fig 2. which shows clear effects of topography and rainfall distribution. The flood developed on the northern part of the catchment moving faster to the downstream because of higher elevation and rainfall in this area during this specific event. In this flood event geomorphologic features of this area controlled the characteristics of the estimated flood hydrograph. The correct timing of the flood peak at the outlet suggest that the advancing flood from the upper reaches can be traced allowing forecast of arrival time of flood in the lower reaches to be made for disaster management.

5 CONCLUSIONS

Geomorphologic factors are important in controlling flood generation and formation since they determine what volume of flood can be generated from a specific area and how it moves downstream to the lower reaches. In addition to this the current study has indicate the importance of considering spatial distribution of rainfall in modeling floods. The emphasis of model design in this study was to capture the effects of spatial distribution of both rainfall and the geomorphic factors. The model provides a frame work for studying the effects of geomorphic factors on flood generation and propagation which are not well understood to date. The framework also may allow process studies and evaluation of different sources of data for flood simulation.

REFERENCES

[1] Kimaro, T.A (2003) Physically based distributed modelling for hydrological impact assessment of catchment environment change. Unpublished thesis Graduate School of Civil Engineering, Kyoto University.