II－4 EFFECT OF GEOMORPHOLOGIC RESOLUTION ON HYDROGRAPH UNDER CHANGE OF STORAGE DESCRIPTION

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1. INTRODUCTION

An uncertainty accompanied with the simulation of distributed model has been studied in order to predict realistically and reliably hydrological response of an ungauged watershed or watershed under circumstance change. The errors come from data, model complexity, calibration and validation. The present study is interested in an effect of geomorphologic resolution connected to data manipulation at different scales. Especially, the effect is examined under consideration of two descriptions of storage concept conducting interflow and baseflow in a model.

2. METHODOLOGY

A series of numerical experiments were performed to assess error caused by geomorphologic resolution with a grid-based model.

2.1 Catchments and geomorphologic resolutions

Here, to identify hydrologic response at different scales, artificial catchments were constructed with areas of 100, 400, 900, 1600 and 2500 km^2 (Fig. 1). The five resolutions were used for model application to investigate the effect of resolution. The resolution was changed as grid size of 50, 100, 250, 500 and 1000 m (Fig. 2).

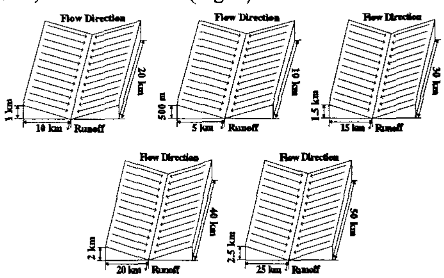


Figure 1. The artificial catchments with area 100 km^2, 400 km^2, 900 km^2, 1600 km^2, and 2500 km^2

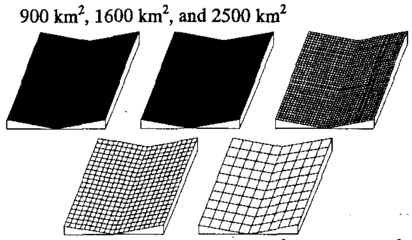


Figure 2. The artificial DEMs at 50×50 m^2, 100×100 m^2, 250×250 m^2, 500×500 m^2 and 1000×1000 m^2 resolution

2.2 Data

The present work is concerned about the effect caused by the only geomorphologic resolution. Therefore we used uniform value for rainfall and other properties of catchment. In other words, it is assumed that all characteristics were homogeneous.

2.3 Model description

A simple distributed model was employed to reduce the uncertainty from complexity of model structure. The grid-based model (Fig. 3) brought a good result of simulation in the study of Tsuchida (2002). A catchment is divided into land flow and channel segments. In the land, water is stored in three tanks laid vertically in series. The overland flow is conducted by the kinematic wave method, while interflow and baseflow are calculated by storage concept. River flow is computed by the dynamic wave method.

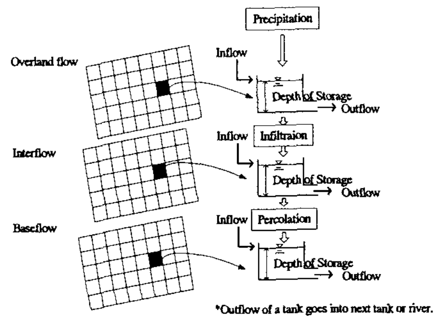


Figure 3. Grid-based rainfall-runoff model

2.4 Storage description

In the model, interflow and baseflow are conceptualized as a series of tank storages. First of all, the water storage of interflow is computed by Eqs. (1), that of baseflow Eqs. (2).

Case1)
$$S = K_1 \cdot q \quad (1)$$
$$S = K_2 \sqrt{q} \quad (2)$$

where S is water depth stored in one tank, q is water depth moving from one tank to next tank, K_1 and K_2 are storage coefficients.

We could expect that constant storage coefficient led to faster hydrologic response with larger grid size of model. Therefore we described the storage coefficient as function of grid size so that rising of hydrograph for each resolution might occur at the same time. Secondly, interflow is conducted by Eqs. (3), that of baseflow Eqs. (4).

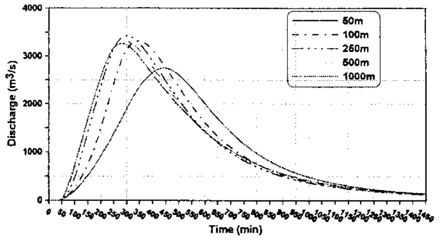
Case2)
$$S = K_1' \cdot \Delta x \cdot q \quad (3)$$
$$S = K_2' \sqrt{\Delta x \cdot q} \quad (4)$$

where Δx is grid size, K'_2 and K'_2 are storage coefficients.

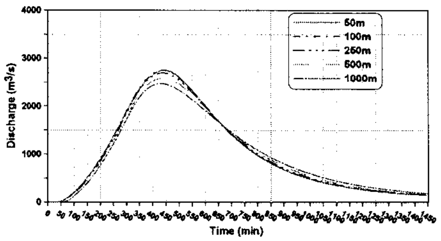
3. RESULTS

One set of hydrographs for catchment area of 2500km^2 is shown in Fig. 4 because all hydrographs have similar shapes under same storage description. Two figures of Fig. 4 show different models for routing of interflow and baseflow. The hydrographs are more lagged at smaller grid size for case 1 as expected while the hydrographs for case 2 are almost same. Peakflow of finest resolution with 50×50 m^2 for case

1 has minimum value because of more increase of round error than decrease of truncation error. On the other hand, every value of peakflows is nearly equal because numerical error occurs similarly at every resolution



(a) Case 1: first model using Eqs. (1), (2)



(b) Case 2: second model using Eqs. (3), (4)

Figure 4. Hydrographs for each storage description

4. DISCUSSION

In order to compare effectively and graphically the results, we computed criteria of relative volume error (EV) and model efficiency (R^2, Nash and Sutcliffe, 1970) and draw error contour maps with axes of resolution and catchment area (Fig. 5 and 6).

$$EV = (V^o - V^s)/V^o \quad (5)$$

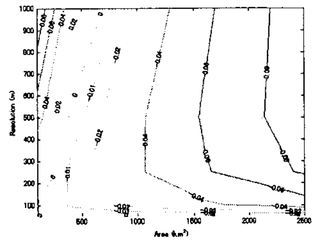
$$R^2 = 1 - \sum_{i=1}(Q_i^o - Q_i^s)^2 / \sum_{i=1}(Q_i^o - \bar{Q})^2 \quad (6)$$

where V is total volume of hydrograph, Q is discharge, superscript 'o' indicates the result of the finest resolution which is error-free, superscript 's' indicates the results of other resolutions, n is the number of time steps from time of rain beginning to time of discharge corresponding to 5% of peakflow. The shape of error contour map is totally different according to storage description. In the figure for case 1, errors are almost same for over resolutions of 250mX250m and might be sensitive to the catchment scale than the grid size. The value of error for case 1 varies with wider range than that for case 2. For case 2, the simulation of smaller catchments requires finer data resolution and the gradient of contour is high for small catchment.

5. CONCLUSIONS

The error contour map could help us to understand graphically which resolution was appropriate at certain scale of catchment. By description of interflow and baseflow as the function of grid size, we could reduce the degree of error variation for resolution and scale changes. In other words, the results showed that models could be insensitive to catchment area and grid size by changing parameter. The results of present work will be basic information to discuss the effect of resolution of spatially distributed data. The study on resolution and scale will assist us to discuss and evaluate both capability of distributed model and accuracy of the result simulated by it.

(a) Case 1



(b) Case 2

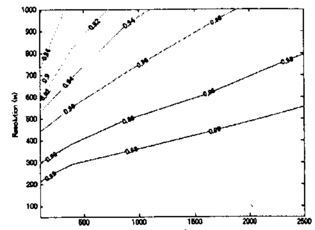
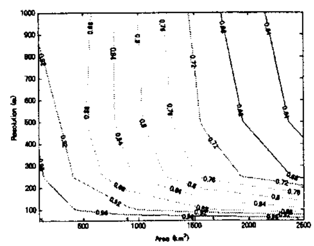


Figure 5. Relative volume error map for storage description

(a) Case 1



(b) Case 2

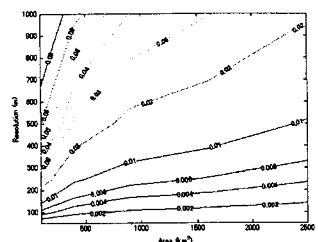


Figure 6. Mode efficiency map for each storage description

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