II －13 **EFFECTS OF DATA AGGREGATION ON RUNOFF SIMULATION FOR IMAGINARY ALTITUDE PROFILES GENERATED FROM DIFFERENT DATA SOURCES**

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1. INTRODUCTION

A resolution in the application of distributed models has been a topical issue. Through poor representation of real world by a coarser resolution, a reliable hydrologic response could be simulated according to data availability, model structure. The present study was carried out in order to understand the effect of data aggregation on runoff under the change of a certain factor related to flow. For that purpose, not a specific catchment with the heterogeneous properties but an imaginary altitude profile was employed. The simulation for the imaginary altitude profile could assist to appreciate the model behavior according to a resolution and a certain property of altitude profile. A grid-based model was applied to imaginary altitude profiles generated to have different topographic properties: mean slope and length of altitude profile.

2. RAINFALL-RUNOFF SIMULATION

The schematic diagram of the distributed model used in the study is shown in Figure 1. The water in land flow is stored in three tanks laid vertically in series. The velocities of outflow from top, second, and third tanks are different one another. The horizontal outflow of the 1st tank is conducted by kinematic wave method while the horizontal outflows of the 2nd and the 3rd tanks are based on Darcy's law. The total runoff from three tanks is the sum of the three horizontal outflows. The infiltration rate from the 1st tank into the 2nd tank is based on Holtan's method. The vertical flow rate from the 2nd tank into the 3rd tank is calculated using the difference between the water depths of two tanks.

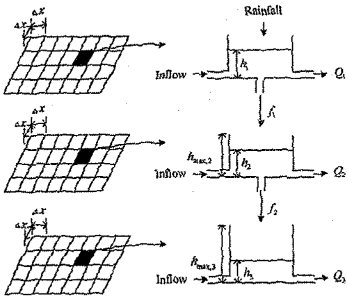


Figure 1 Schematic diagram of a distributed runoff model

Time step of 1 second and grid sizes of 50m, 100m, 250m, 500m and 1000m were employed for the application of the grid-based model. All parameters of the model were assumed to be homogeneous temporally and spatially in order to avoid effects encountered by another factors. Storm event of rainfall intensity of 50 mm/hr with duration of 1 hour was used. The rainfall was, also, assumed to be uniform spatially and temporally.

3. IMAGINARY ALTITUDE PROFILES

For the generation of the imaginary altitude profiles, relative frequency of altitude data was investigated from DEMs of resolution of 50mX50m. Figure 2 shows the data distribution for Han-river, Nakdong-river, Keum-river basins located in South Korea. The total number of data was calculated from Eq. 1 after the length of altitude profiles was assumed to be 2, 4, 6, 8 or 10 km. Then, the altitude data required for one altitude profile were generated on the basis of the distribution of relative frequency in Figure 2. Each generated altitude data was allocated into each cell with grid size of 50m. Figure 3 shows an instance of the generated imaginary altitude profiles and the mean slope of altitude profiles depending on the data sources of the basins. However, it was difficult to understand the effect of mean slope and the length through the simulations for the imaginary altitude profiles. This was because the irregularity of surface affecting considerably runoff was quite different according to the data source. For the purpose of eliminating the effect of the surface irregularity, new altitude profiles with exponential shape were constructed using the fit curve of Eq. 2 (Fig. 3). We could, therefore, concentrate upon the effect of mean slope of altitude profile. Table 1 shows the estimated coefficients of Eq. 2 and the mean slope of altitude profiles. The change of data source and the length can be expressed as c_1 and c_2, respectively.

$$TN = L/\Delta x^{50} \quad (1)$$

where, TN is the total number of altitude data, L is the length of altitude profile (m) and Δx^{50} is the grid size of 50 (m) as the reference.

$$z = c_1 e^{c_2 \times L} \quad (2)$$

where, z is the altitude value (m), L is the length of altitude profile (m), c_1, c_2 are coefficients.

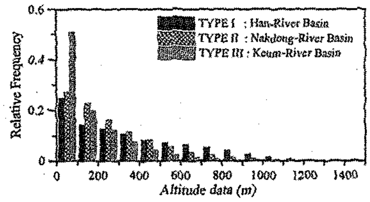


Figure 2 Relative frequency of altitude data for each data source

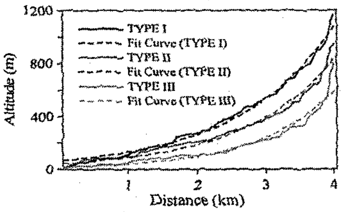


***Figure* 3** Exponential and rough altitude profiles (4km)

Table 1 Exponential fit curve and mean slope (S) of altitude profile

Length	TYPE I			TYPE II			TYPE III		
(km)	c_1	c_2	S	c_1	c_2	S	c_1	c_2	S
2	65	0.001397	0.5097	42	0.001447	0.3690	16	0.001734	0.2597
4	65	0.000701	0.2548	42	0.000743	0.1980	16	0.000897	0.1456
6	65	0.000470	0.1725	42	0.000502	0.1370	16	0.000609	0.1033
8	65	0.000355	0.1321	42	0.000371	0.0984	16	0.000463	0.0813
10	65	0.000285	0.1065	42	0.000299	0.0807	16	0.000367	0.0628

4. DATA AGGREGATION

The data aggregation for the 15 imaginary altitude profiles generated for the resolution of 50mX50m was carried out according to five grid-sizes of the distributed model. An instance of the data aggregation is presented in Figure 4. As expected, the coarser resolution shows poorer representation of the original altitude profile. The rainfall-runoff model was, therefore, applied to the 75 altitude profiles generated by the combination of data source, length, and resolution.

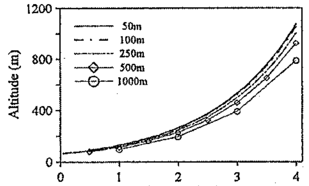


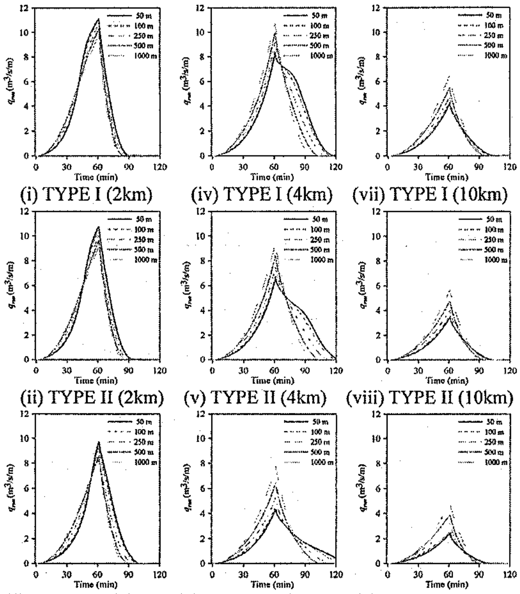
Figure 4 Data aggregation of altitude profile (TYPE I, 4km)

5. RESULTS AND DISCUSSION

As the results of the simulations for altitude profiles, some hydrographs are shown in Figure 5. The hydrographs for 6km and 8km are not presented owing to the similarity with those for 10km. The hydrologic response was different according to the mean slope (TYPE I, TYPE II and TYPE III) and the length of altitude profile (2km~10km). Lower peakflow occurred from the generation of more infiltration as the mean slope became milder and the length became longer. The comparison of the simulations for the altitude profiles generated from different data sources showed that their hydrographs had the similarity despite of different discharge. The change of the length affected considerably the runoff simulation at small scale while the hydrographs with similar shape were produced in the simulations for the length of 6km and over.

The data aggregation by the coarser resolution led faster hydrologic response and higher peakflow in most cases expect for 2km. The winding of hydrograph well detected in the simulation of the finer resolution for shorter length and steeper mean slope could not be simulated with the coarser resolution. Runoff delay shown in the build-up phase or the attenuation phase of hydrograph of the finer resolution was not observed in the hydrographs of the coarser resolution (Fig. 5-i~5-vi). The coarser description of topography would simplify the hydrologic response. The hydrologic response of the finest resolution, also, became simple together with the longer length. In this case, the difference between the resolutions could be explained as the change of discharge without the large fluctuation in shape of hydrograph.

Contour maps for the model efficiency coefficient (Nash and Sutcliffe, 1970) were constructed in order to compare graphically the difference between resolutions (Fig. 6). The criterion was calculated assuming that the simulation of the finest resolution was error-free. The error increased with coarser resolution or milder mean slope but its trend for length was not consistent. The model efficiency mostly decreased with longer length but more error occurred in the simulations for 4km (Fig. 6-i, Fig. 6-ii). This was because the coarser resolution for 4km could not simulate the delay of runoff of the finest resolution (Fig. 5-iv, Fig. 5-v) and the runoff of the finest resolution was stabilized at the lengths of 6km and over (Fig. 5-vii, Fig. 5-viii). If the model efficiency of over 0.8 is required, the use of the grid size of 1000m is unallowable in case of TYPE I or TYPE II and the grid sizes of 500m and 1000m is unallowable in case of TYPE III.



(i) TYPE I (2km) (iv) TYPE I (4km) (vii) TYPE I (10km)
(ii) TYPE II (2km) (v) TYPE II (4km) (viii) TYPE II (10km)
(iii) TYPE III (2km) (vi) TYPE III (4km) (ix) TYPE III (10km)

Figure 5 Hydrographs

6. CONCLUSIONS

A series of experiments for the imaginary altitude profile showed the model behavior according to the resolution, the mean slope, and the length. The effect of data aggregation on runoff simulation was dependant on the topographic condition. In the present study, the length of altitude profile had more influence on the runoff than the mean slope changed by the data source. The milder slope and the longer length required the finer resolution in the simulation for the altitude profile with the exponential shape. If the hydrologic response of the finest resolution is interpreted through the coarse resolution, the result of the coarse resolution is analyzed quantitatively at large scale owing to the similarity in shape of hydrograph. On the other hand, we should keep it in mind that the significant change in shape of hydrograph could occur by eliminating the delay of runoff in case of small scale.

ACKNOWLEDGMENTS

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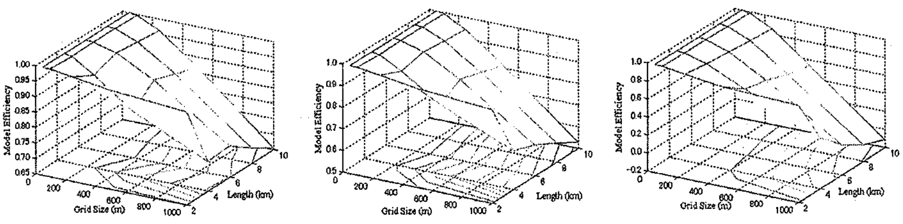

(i) TYPE I (ii) TYPE II (iii) TYPE III

Figure 6 Error contour maps