EFFECT OF SPATIAL RESOLUTION ON HYDROGRAPH AT VARIOUS SCALES

HYEJIN KU [1], SO KAZAMA [2] and MASAKI SAWAMOTO [3]

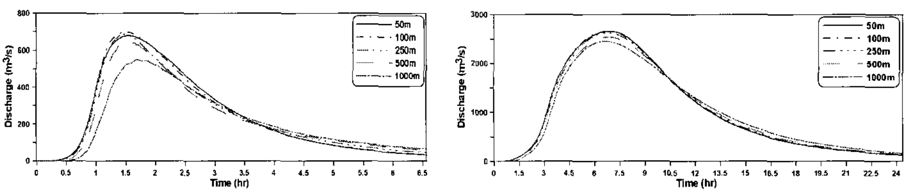
[1] Student, Department of Civil Engineering, Tohoku University,
Aobayama 6-6-06, Aoba, Sendai, 980-8579, Japan
(Tel: +81-22-795-7459, e-mail: kuhyejin@kaigan.civil.tohoku.ac.jp)
[2] Associate Professor, Graduate School of Environmental Studies, Tohoku University,
Aobayama 6-6-20, Aoba, Sendai, 980-8579, Japan
(Tel: +81-22-795-7458, e-mail: kazama@kaigan.civil.tohoku.ac.jp)
[3] Professor, Department of Civil Engineering, Tohoku University,
Aobayama 6-6-06, Aoba, Sendai, 980-8579, Japan
(Tel: +81-22-795-7457, e-mail: sawamoto@mail.tains.tohoku.ac.jp)

A number of distributed models have been developed for prediction of hydrologic response of an ungauged catchment or a catchment under circumstance change with more reliability than the lumped models. The distributed models include, however, inevitable uncertainty from model structure, data, calibration and validation (Beck, 1987, Beven and Binley, 1992). Quantification and evaluation of the uncertainty should be studied for the trustworthy application of distributed models with previous parameterization (McIntyre et al., 2004). In order to reveal the uncertainty in advance for practical and proper application of a distributed model, we carried out a series of experiments for combination of both resolution of spatial data and scale of catchment. Especially, the effects of topology and rainfall resolutions were investigated by employing spatially variant and invariant rainfall types. A grid-based model was applied to five imaginary catchments with different areal extents of 100, 400, 900, 1600 and 2500 km^2. The grid sizes of 50, 100, 250, 500 and 1000 m were employed for the resolution change. The other data were kept as homogeneous to avoid encountered effects by them.

First of all, we present results of rainfall-runoff simulations for spatially variant rainfall type. The only one set of hydrographs for catchment with 100, 2500km^2 is shown in Fig. 1 because all hydrographs have similar shapes. The figures show that coarser resolution could bring poor result in the simulation for the small catchment. There is almost no difference of hydrographs for resolutions because storage coefficients conducting interflow and baseflow were defined as a function of grid size (Ku *et al.* 2005). Model efficiency (Nash and Sutcliffe, 1970) was calculated assuming that the result with finest resolution was error-free in order to compare the variation of result by resolution change. A contour map for the error is drawn with axes of the resolution and the scale in Fig. 2. The contour map indicates that finer resolution is required for simulation of smaller catchment and the gradient of contour is high for small catchment. Secondly, the result for average rainfall was compared with that for spatially variant rainfall in Fig. 3. Each error was calculated referring to the discharge of the finest resolution for non-uniform rainfall. The figure shows that the error is nearly same regardless of rainfall shape at the identical resolution. Namely, the resolution of the topology than the rainfall has more influence on hydrograph. This is because the non-uniform rainfall used in the study is a center-concentrated shape without high heterogeneity spatially.

The most simulations met with good results. The simulation for catchment with small scale was more influenced by resolution under the condition used in this study. The comparison between errors of two rainfall types indicated that an employment of uniform rainfall was proper in simulation for design rainfall by areal reduction factors. It means topologic resolution is likely to have more influence on hydrograph than rainfall resolution under the condition used the present study. A required data type and an important degree of certain data could be changed according to a model structure and catchment characteristics. We could consent again that model capability and uncertainty should be revealed in advance for practical and proper application of a distributed model.

The present study showed, however, some experiments to only imaginary catchments leaving out of consideration of real world. We agree that it is required to represent a probable catchment through an analysis of real topology and then we are able to obtain more reliable and valuable information on effects of resolution and scale. The study on resolution and scale will assist some unexperienced users to approach a reliable result through proper data manipulation and us to discuss and evaluate the capability of the distributed model and the accuracy of the result simulated by it.



(a) Catchment with 100 km^2

(b) Catchment with 2500 km^2

Fig.1 Hydrographs for spatially variant rainfall

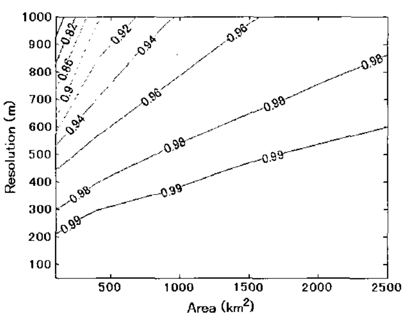


Fig. 2 Contour map for model efficiency

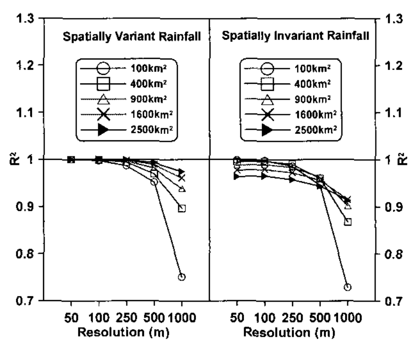


Fig. 3 Comparison of mode efficiency for spatially variant and invariant rainfall types

REFERENCES

Beck M.B. (1987). "Water quality modeling: a review of the analysis of uncertainty", *Water Resources Research*, Vol.23(5), pp. 1393-1441.

Beven K., Binley A.M. (1992). "The future of distributed models: Model calibration and uncertainty prediction", *Hydrological Processes*, Vol.8, pp. 279-298.

Ku H.J., S. Kazama, S. and M. Sawamoto (2005). "Effect of geomorphologic resolution on hydrograph under change of storage description", *Proceedings of JSCE Tohoku*, pp. 118-119.

Nash J.E. and Sutcliffe I.V. (1970). "River flow forecasting through conceptual models, part I", *Journal of Hydrology*, Vol.10, pp. 282-290.

McIntyre N.R.and Wheater H.S. (2004). "Calibration of an in-river phosphorus model: prior evaluation of data needs and model uncertainty", *Journal of Hydrology*, Vol.290, pp. 100-116.