The Effects of DEM Resolution on Hydrological Simulation in BASINS-HSPF Modeling

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Abstract: In this study, the effect of DEM resolution (15m, 30m, 50m, 70m, 100m, 200m, 300m) on the hydrological simulation was examined using BASINS (Better Assessment Science Integrating point and Nonpoint Source) for Heukcheon watershed (303.3km2) data from 1998 to 1999. Generally, as the cell size of DEM increased, topographical changes were observed as the original range of elevation decreased. The processing time of watershed delineation and river network needed more time and effort on smaller cell size of DEM. The larger DEM demonstrated had some errors in the junction of river network which might effects on the simulation of water quantity and quality. The area weighted average watershed slope became lower but the length weighted average channel slope became higher as the DEM size increased. DEM resolution affected substantially on the topographical parameter but less on the hydrological simulation. Considering processing time and accuracy on hydrological simulation DEM mesh size of 100m is recommended for this watershed.
Key words : DEM, Resolution, BASINS, HSPF, Hydrological simulation, GIS

1. INTRODUCTION

The advent of GIS has already profoundly affected the hydrologic modeling community. GIS provides excellent capabilities of data preparation for watershed and receiving water modeling. More recently, models are being tightly linked with GIS, allowing user to modify data and analyze resulting model output within the GIS environment. In GIS modeling system, topography such as DEM (digital elevation model) defines the effect of gravity on the movement of water in a watershed, and affects the hydrologic system and soil erosion (Wolock and Price, 1994). Topography has been shown to affect the flow path that precipitation flows before it becomes streamflow (Wolock et. al., 1990), the spatial distribution of soil moisture within a watershed (Burt and Butcher, 1985), and the chemical characteristics of streamflow (Wolock et al., 1989, 1990). In this study, the sensitivity of the geomorphologic parameter and hydrological responses to the different DEM resolution was investigated in Heukcheon watershed using two years data of 1998~1999. The effect of DEM resolution on the catchment hydrological response in BASINS simulation is presented in this paper.

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2. MATERIALS & METHODS

Study area

The study area is a Heukcheon watershed located in Yangpyeong-gun, Gyunggi-do, Korea(Fig.1). The catchment area is 303.3 km^2 and length of main channel is 37.7 km. The water level gage station is located at the downstream of the watershed and shown in Fig. 1 and water-level record is available (Water Resources Management Information System, 2002)

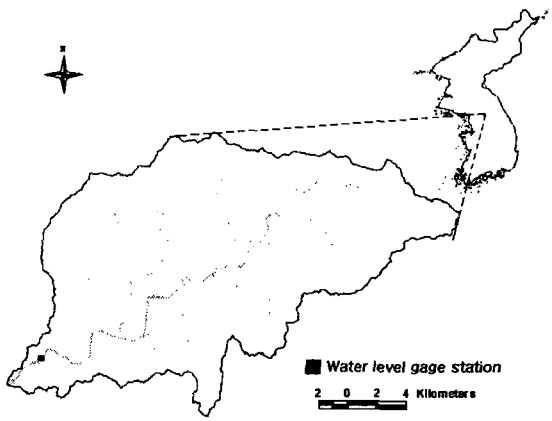

Fig. 1. Location of study area and water level gage station.

Application

DEMs for the study area were derived independently at 15m, 30m, 50m, 70m, 100m, 200m, and 300m resolution by interpolation from 1: 25,000 scale digital map using GIS program, ArcView 3.2a. Watershed delineation and stream definition were generated by BASINS-Delineation tool, and geomorphologic parameters were extracted for each DEMs. Landuse provided by M.O.E (Ministry of Environment) was used for BASINS-Utility tool. HSPF input file was produced automatically in BASINS system for each DEMs, using geomorphologic data, landuse data and hourly weather data.

To examine the response of geomorphologic parameter on DEM resolution, geomorphologic parameters of area weighted slope of watershed and length weighted slope of main stream are used in the form as follow.

$$Area\ weighted\ slope\ of\ watershed = \frac{\sum(basin\ area \cdot slope\ of\ basins)}{\sum total\ area} \cdot 100$$

$$Length\ weighted\ slope\ of\ stream = \frac{\sum(basin\ area \cdot slope\ of\ stream)}{\sum total\ length} \cdot 100$$

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3. RESULTS & DISCUSSION

Watershed delineation and stream definition

The processing times for watershed delineation tasks decreased as the DEM resolution became coarser (Table 1). Among the watershed delineation processes, the calculation of subbasins which extracts watershed parameter for each subbasins needs more time than any other processes.

Table 1. Comparison of processing times for watershed delineation tasks with different DEM resolution (Unit : seconds)

	15m	30m	50m	70m	100m	200m	300m
The number of cells (1,000)	1,356.8	339.0	121.9	62.2	30.5	7.6	3.4
Procedure time	2,795	763	424	307	225	113	79

The hydrological simulations were carried out from 1998 to 1999 for the study area. Initially, the 15m DEM was used to provide the spatial parameterisation for input file, and the results of calibration and verification of runoff are shown in Fig. 2 where model efficiency was 75.6%.

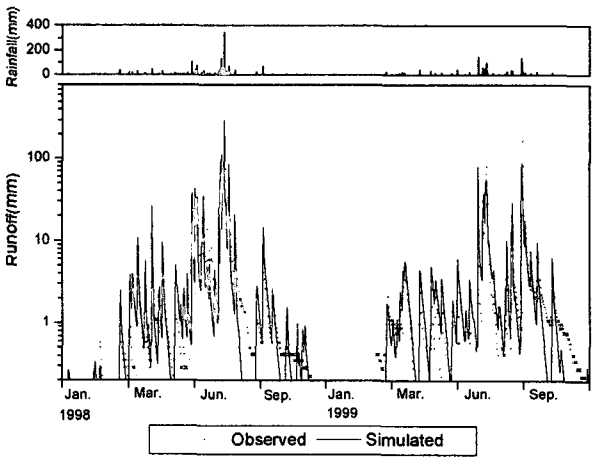

Fig. 2. Calibration and verification of daily runoff depth using BASINS-HSPF

The effect of DEM resolution on the topographical parameter

The area weighted slope of watershed became flat and the length weighted main slope of stream became steep systematically as the DEM mesh size increased (Table 2).

Yearly runoff during 1998 was 1,105.4mm by 15m resolution. The yearly runoff was

smaller until 100m resolution as 1099.0mm but from 200m to 300m resolution was higher for a coarser scale (Table 3). Similar pattern appeared during 1999. However, the relative errors of yearly runoff with DEM resolution were within 0.6%.

Table 2. The sensitivity analysis of DEM resolution on hydrological simulation

	15m	30m	50m	70m	100m	200m	300m
Errors of subbasin's slop	0.0	-7.9	-17.0	-23.9	-32.0	-48.9	-58.9
Errors of stream's slop	0.0	0.9	0.7	-0.6	2.1	25.2	49.8

Table 3. Comparison of yearly runoff simulation from different DEM mesh size(Unit : mm)

Year	15m	30m	50m	70m	100m	200m	300m
1998	1,530.7	1,529.8	1,528.8	1,529.1	1,521.3	1,526.3	1,531.0
1999	1,105.4	1,105.1	1,103.7	1,103.8	1,099.0	1,102.9	1,105.4

This study demonstrated that DEM resolution much influenced topographical parameter such as the slope of watershed and stream, however it influenced less on hydrological simulation like yearly runoff. The processing time of 15m resolution was much more than that of 100m resolution, but the hydrological simulation result was almost identical. Therefore, the adequate DEM resolution for BASINS-HSPF hydrological simulation might be about 100m in larger than mid-scale watershed (>300 km^2) considering efficiency and accuracy.

4. CONCLUSION

As the TLCS (Total Load Control System) started for the major rivers in Korea, integrated modeling system like BASINS which was linked GIS is expected to be used more frequently. In this system, data quality is important for accurate simulation. However, fine resolution and high classification of GIS data need more processing time and efforts for developing GIS data. Further investigation for the effects of GIS resolution of water quality simulation as well as hydrological simulation is recommended considering cost and accuracy.

5. REFERENCES

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