TA-127L

DEVELOPMENT OF ULTRA-HIGH RESOLUTION DISTRIBUTED RAINFALL RUNOFF MODEL TO FORECAST FLASH FLOOD IN UNGAUGED URBAN CATCHMENTS

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Background

Under the impact of Climate Change, occurrence of serious hydrological events showed an increasing tendency in recent years. According to World Water Development Report 2020 (WWDR), global floods and extreme rainfall events have surged by more than 50% this decade and are now occurring at a rate 4 times higher than in 1980. Distributed Hydrological Model (DHM) based on topography and precipitation data has been widely used in river discharge predictions. 1K-DHM-event, as one of the distributed hydrological models based on kinematic wave equations, showed reliable performances focused on large-scale catchments in Japan and other regions according to previous research.

However, as population growth and urbanization rapidly increasing, floods happened frequently in relatively small-scale urban catchments. In 2012 and 2013, two floods happened in Midajiro river with a catchment area of 1.44km^2 and Hata river with a catchment area of 1.52km^2 in Kyoto Prefecture. Both of the two catchments are extremely small without observation devices but caused inundation, house damage and economic loss.

Research Purpose

This research is purposed to develop a discharge prediction method integrated 1K-DHM-event with high-resolution rainfall data in ungauged urban area.

Research Method

To make rainfall-runoff simulations by applying 1K-DHM-event model, three necessary input data and comparison discharge data should be prepared. 1) For topographic data, 1s resolution Digital Elevation Model (DEM) data was used, which also contributes to generate 34 catchments as our target area in Osaka Area. 2) High-resolution radar data X-RAIN with 1min interval was chosen as input precipitation data. 3) 5 hydrological parameters in 1K-DHM may vary from different types of land use were taken into consideration which refers to Manning's coefficient of river (Nr), Manning's coefficient of slope (Ns), Hydraulic conductivity (Ka), Soil depth (Da) and Capillary soil depth (Dm). 4) Finally, water level data with rating curves were supposed as discharge observation data for comparison.

Though we can easily get the first 2 input data for 1K-DHM, to identify suitable hydrological parameters for different land use is still a remained question. This question divided the research into 3 parts which leads to parameters identification, parameters calibration and parameters validation.

First of all, Yamada River Basin (Figure 1), which locates in the north part of Osaka and contains 14 types of different land use was selected for parameters identification. Rainfall event in 2014 from 23th August to 26th August and Rational Method results with different land use runoff coefficients (f) were chosen as rainfall pattern and discharge references. Secondly, In Northern Osaka, rainfall event in 2015 from 16th July to 19th July was chosen for parameters calibration in 12 catchments. While rainfall event in 2017 from 1st October to 24th October was chosen for that in 22 catchments which locate in Southern Osaka Area. Finally, rainfall event in 2018 from 4th July to 6th July will be applied to validate the performance of parameters in whole Osaka Area.

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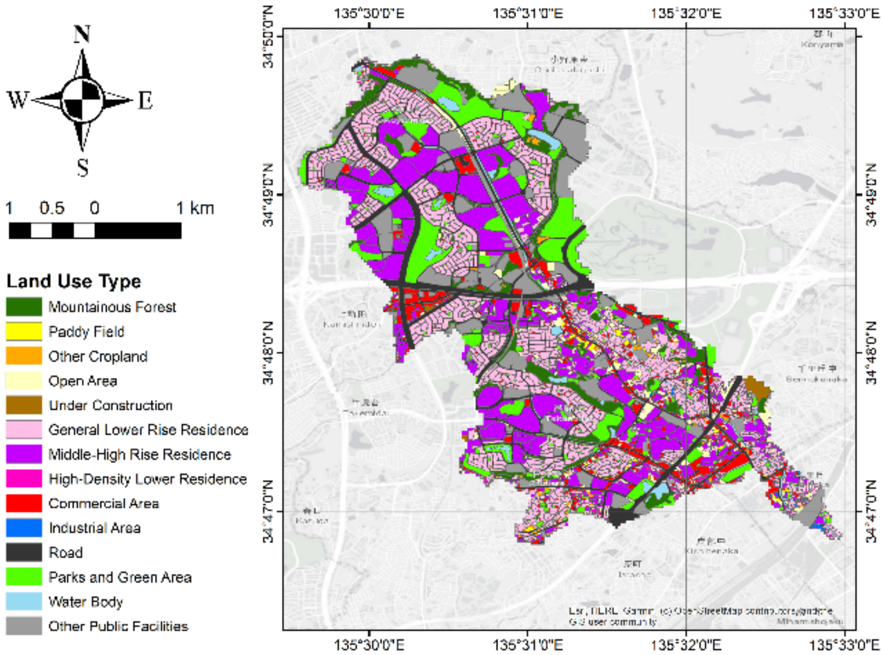

Figure 1 Land use distribution of Yamada River Basin

Current Results

1) Catchment extraction

34 catchments distributed in Osaka Area were extracted with land use information named by the first letter of the district name and following with a number such as I1, I2, I3, etc.

2) Parameter identification

Table 1 Identified hydrological parameters

Land Use Type	f	Ns	Ka[m/s]	Da[m]
Mountainous Forest	0.5	0.6	0.002	0.1
Paddy Field	0.7	0.7	0.002	0
Other Cropland	0.45	0.3	0.002	0.13
Open Space	0.2	0.3	0.002	0.245
Under Construction	0.2	0.3	0.002	0.245
General Lower Rise Residence	0.8	0.03	0.002	0.114
Middle-High Rise Residence	0.8	0.03	0.002	0.114
High-Density Lower Residence	0.8	0.03	0.002	0.114
Commercial Area	0.8	0.03	0.002	0.114
Industrial Area	0.8	0.03	0.002	0.114
Road	0.9	0.03	0.002	0.099
Parks and Green Area	0.65	0.3	0.002	0.234
Public Facilities	0.21	0.03	0.002	0.132
Water Body	1	0.027	0	0
Others	0.65	0.03	0.002	0.132

Besides the parameters above in Table 1, Ns is 0.027 for all kinds of land use types.

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3) Parameter performance

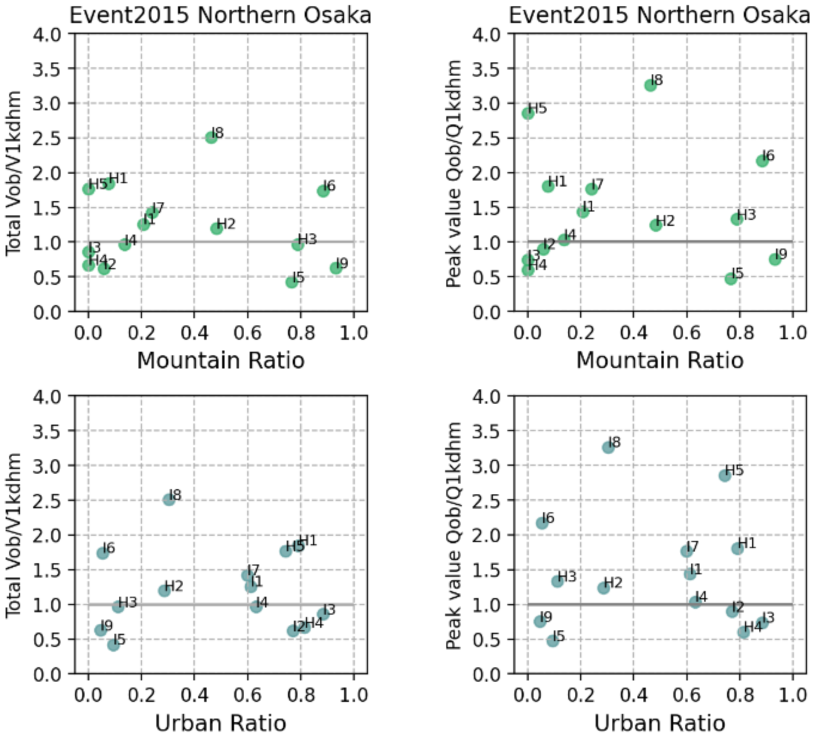

Figure 2 Total discharge comparison in Northern Osaka Area according to mountainous forest ratio and urbanized area ratio

Figure 3 Peak discharge comparison in Northern Osaka Area according to mountainous forest ratio and urbanized area ratio

For the 12 catchments located in Northern Osaka, discharge simulation performances differ from catchment to catchment. To analyze how the current parameters identified affect simulation performances, the comparison between simulation discharge applied by 1K-DHM and observation discharge according to mountainous area ratio and urbanized area ratio were carried out as Figure 2 and Figure 3.

Conclusions

Generally, for the current parameter performance showed in Northern Osaka Area, both the total discharges and peak discharges were under estimated as mountainous ratio increases. Meanwhile they were both over estimated as urban ratio is increasing. The results provide us an indication that perhaps Da should be smaller in mountainous area while Da should be larger in urbanized area for the future research.

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Keywords: discharge forecast, distributed rainfall-runoff model, ungauged urban catchments

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