Evaluation of QPE for the Rainfall-Runoff Analysis in Urban Area

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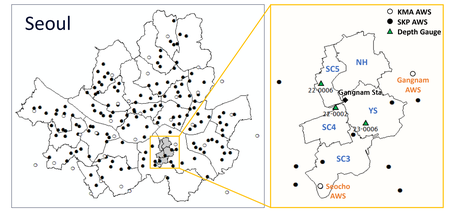
Introduction

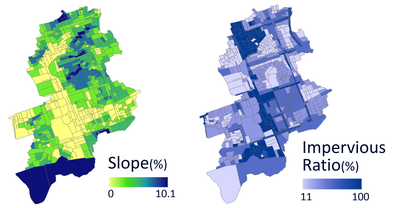
- The occurrence of local torrential rainfall has been increased, and it resulted huge casualties and property damage from 2010 in Seoul, Korea.
  - September 21, 2011 : $17million / July 27, 2011 : $31million
- Rainfall-runoff analysis is necessary to develop forecast model for urban flash flood.
  - development of runoff model based on the real event in the past
  - evaluate of the model using in situ data(eg. Depth in manhole, discharge, flooding map etc.)
- Using high quality weather information with verified tools could improve the accuracy of flood forecast.
- In this study, rainfall-runoff analysis using SWMM(Storm Water Management Model) was performed for Gangnam Station area, southern areas of Seoul.

Set up input data using GIS DB (drainage network, manhole, DEM, Landuse) → Application of 4 QPEs as precipitation input data → Sewer network analysis using SWMM → Validation using in situ data (depth in manhole)

Study Area

- Gangnam area is in the southern part of Seoul.
- There are two AWS(Automatic Weather Station) of KMA(Korea Meteorological Administration) and three available depth gauges in the area.
- Five drainage districts near Gangnam station including one each in Nonhyun(NH), Yeoksam(YS) and Seocho(SC)3, 4, 5 were selected as target areas.
  - the areas of these districts are 1.8 km^2, 1.9 km^2, 1.8 km^2, 1.1 km^2 and 0.8 km^2, respectively.
- The average slope, calculated by 5-m resolution DEM(Digital Elevation Model) was 1.801%.
- Impervious ratio and CN(Curve Number) were determined by using biotop map, and the range of them were 47~95 and 10.6~100%, respectively.
- The drainage system consists of 4,170 manholes and total 200,698-km length of pipelines.
  - to obtain input data for runoff analysis, 773 manholes, 1,059 pipes, and 772 sub-drainage basins were used for SWMM.



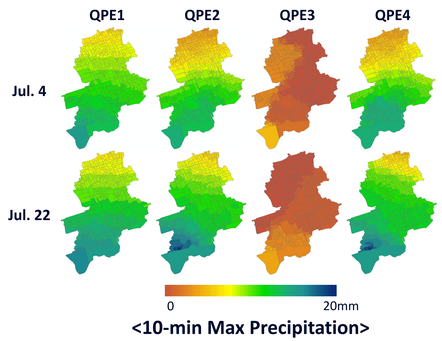


QPEs Using High Density Gauge Network

- Rainfall events : July 2, 4, 12-14, 15, 22 and 23, 2013
  - There are spatial and temporal difference between GN and SC AWS(distance : 3.7km) in a event.
  - The maximum deviation of 10-min rainfall intensity between GN and SC AWS is 11.5mm(at 6:10, July 22, 2013).
- Rainfall input data was constructed by MAP(Mean Areal Precipitation) for each sub-district basins from four types of QPEs(10min/250m).
  - QPE1 : Kriged rainfall field using 34 KMA AWS data
  - QPE2 : Kriged rainfall field using 190 gauge data from KMA(34) and SKP(156) AWS
    * SKP(SK Planet) : Digital contents business and marketing company
  - QPE3 : Radar rainfall field from KMA(Res. 1km) and Radar rainfall field using UF data
  - QPE4 : Conditional merged rainfall field using QPE2 and QPE3
    * Conditional merging : The technique extracts information from the observed data by using ordinary kriging and combines it with radar rainfall data to improve radar rainfall estimates.
- QPE2 and QPE4 have similar rainfall field and bigger variation than QPE1.
- QPE3 underestimates the precipitation about 26.2~58.5% than GN and SC AWS data.

<Rainfall Events and Characteristics>

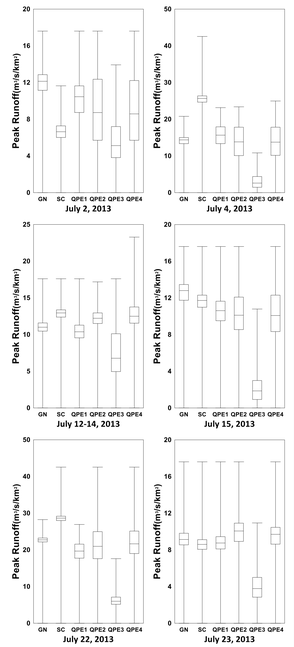
Event	AWS Site	Total Rainfall	Max. Rainfall Intensity 10 min.	Max. Rainfall Intensity 60 min.	Max. Deviation
Jul. 2	GN	37.9	8.0	16.0	3.5
	SC	33.4	4.5	12.5	
Jul. 4	GN	28.0	9.3	23.9	6.7
	SC	34.5	16.0	32.0	
Jul. 12-14	GN	191.5	7.0	24.4	4.5
	SC	183.5	8.0	33.2	
Jul. 15	GN	22.4	8.5	13.5	4.0
	SC	23.4	7.5	14.0	
Jul. 22	GN	130.7	14.0	60.0	11.5
	SC	124.0	17.5	63.6	
Jul. 23	GN	43.2	6.0	22.8	4.0
	SC	36.3	5.5	19.5	



<10-min Max Precipitation>

Rainfall-Runoff Analysis

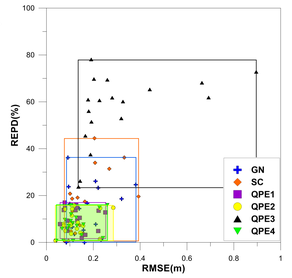
- To evaluate of QPEs for the runoff analysis in urban area, GN and SC AWS data were used as input data with 4 QPE data.
- Peak runoff of each sub-drainage districts show spatial variation as rainfall.
  - When AWS data were input for the analysis, the variation were smaller than QPEs.
  - When QPE2 and QPE4 were input data, they show the biggest variation.
  - QPE3 shows spatial variation, however, the value is lower than the others.
- The simulated depth in manhole were compared with in situ data.
  - QPE4 has the highest accuracy with 0.126m of RMSE(Root Mean Square Error) and 7.830% of REPD(Relative Error of Peak Depth) followed by QPE2, QPE1 and QPE3 on average.
  - GN and SC AWS data have results depend on the distance from the location of depth gauge.
- It is difficult to quantitatively evaluate effect of the variation of rainfall on runoff analysis, however, it could be sure that QPEs help to improve the accurate of urban runoff analysis.



<Distribution of Peak Runoff>

<Average RMSE and REPD>

Rainfall Data	RMSE (m)	REPD (%)
GN	0.165	13.276
SC	0.162	16.330
QPE1	0.128	9.965
QPE2	0.128	8.420
QPE3	0.333	57.211
QPE4	0.126	7.830



Conclusion

- Rainfall input data from AWS gauge data and QPE field data were evaluated for urban runoff analysis.
- QPEs show spatial variation in a small area, and it affected the distribution of peak runoff in each sub-drainage districts.
- When QPE2 and QPE4 were input for the analysis, the accuracy for water depth was highest followed by QPE1 and QPE3.
- Thus, using QPEs which show spatio-temporal variation well is more efficient to analyze of runoff for the local torrential rainfall in complex urban area.

This work was funded by the Korea Meteorological Administration Research and Development Program under Grant Weather Information Service Engine(WISE) project, KMA-2012-0001.