Effects of different spatial and temporal rainfall data resolution on hydrological response in flat urban catchments

Cristiano, E.; Ten Veldhuis, J. A.E.; Van De Giesen, N. C.

DOI
10.3929/ethz-a-010549004

Publication date
2015

Document Version
Final published version

Citation (APA)
Cristiano, E., Ten Veldhuis, J. A. E., & Van De Giesen, N. C. (2015). *Effects of different spatial and temporal rainfall data resolution on hydrological response in flat urban catchments*. Paper presented at 10th International Workshop on Precipitation in Urban Areas: Rainfall in Urban and Natural Systems, UrbanRain 2015, Pontresina, Switzerland. https://doi.org/10.3929/ethz-a-010549004

UrbanRain15

10th International Workshop on Precipitation in Urban Areas
1-5 December 2015, Sporthotel Pontresina, Switzerland
http://www.ifu.ethz.ch/urbanrain/

Proceedings

DOI: 10.3929/ethz-a-010549004

Rainfall in Urban and Natural Systems

Edited by

Peter Molnar & Nadav Peleg

Institute of Environmental Engineering
ETH Zurich, Switzerland

Zurich, 2015

Effects of different spatial and temporal rainfall data resolution on hydrological response in flat urban catchments

E. Cristiano*[1], J. A. E. ten Veldhuis[1], N. C. van de Giesen[1]

1 Water Management Department, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, Netherlands

*Corresponding author: E.Cristiano@tudelft.nl

Abstract

Flooding in urban areas is one of the main weather-related risk problems of the last decades. It is due to the fact that the population is growing and moving from the rural areas to the cities, which become more urbanized and densely populated. This phenomenon is combined with the climate changes of the last years, that present an increase of short but quite intense rainfall events. These conditions determine a fast and short-time response of the catchments, which increases the probability of flooding.

Previous researches have studied the sensitivity of different spatial and temporal resolutions on urban catchments, highlighting correlations between the rainfall resolution and the model scales (Bruni et al., 2015, Ochoa-Rodriguez et al., submitted). In particular Ochoa-Rodriguez et al.(submitted) considered the impact of different combinations of spatial and temporal resolutions on hydrological response in seven urban catchments, with the aim to identify critical resolutions. The study shows that the models are more sensitive to variations in temporal resolution than in spatial resolution and that there is a strong relation between the drainage area and the critical rainfall resolution: the effects of the different rainfall resolutions decrease with increased size of the subcatchment considered. The catchments investigated are located in areas with different geomorphological characteristics, and they present different extension, shape, slope, degree of imperviousness and drainage system.

In this study we focus on those catchments that do not have a relevant slope, and where the water that flows in system is mostly not moved by gravity. Instead, there are pumping stations and weirs that allow water to flow in different directions. Moreover, the drainage system is extremely looped, and the water can follow different patterns depending on the conditions of the system. The discharge in specific pipes is not enough to characterize the behaviour of the drainage system, because the flux can change direction and it presents an alternation of positive and negative peaks (Fig.1). The behaviour of these systems is difficult to understand and it is still poorly investigated. A statistical analysis is applied to try to better characterize the behaviour of the system, and the effects that different rainfall input resolutions can have on the hydrological response of the model.

Some districts of the city of Rotterdam (NL) are considered to investigate the behaviour of the drainage system in a flat urban area. Rotterdam is built in a polders area with ground levels below sea level. For this reason, during heavy rainfall, excess storm water needs to be pumped out to the river system or temporally stored.

To better understand the hydrological response of the catchment, high resolution rainfall data are required as input of the model. High resolution data are provided by the dual polarimetric X-band weather radar, located in Cabauw Experimental Site for Atmospheric Research (CESAR) of the Netherlands. The data are provided with different high spatial (from 100m up to 3000m) and temporal (from 1min to 10min) resolutions. Different combinations of spatial and temporal resolutions are considered to evaluate the sensitivity of the hydrological model to different input data. Storms

with different characteristics, such as intensity, duration and velocity, are selected for this study to understand how these parameters can influence the sensitivity of the model.

Results confirm the higher sensitivity of the hydrological response to the temporal resolution than to the spatial resolution presented in the previous studies (Ochoa-Rodriguez et al., submitted), and show that the characteristics of the storm have a strong influence on the output. Scenarios where rainfall events present lower average intensity and higher storm movement velocity tend to be more sensitive to the different spatial and temporal resolutions, presenting different outputs depending on the rainfall resolution used (Fig. 2).

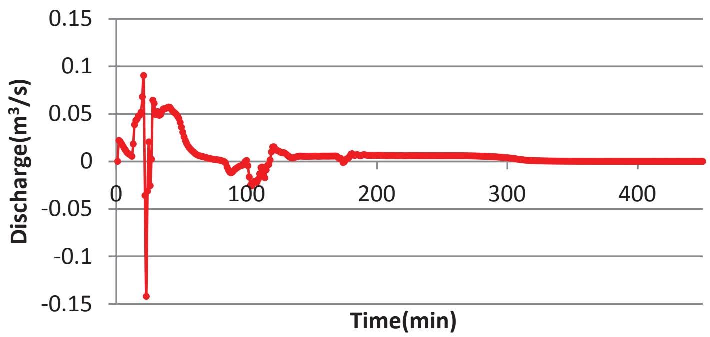

Fig. 1: Discharge in a pipe that drains an area of 2ha, during a storm with a low rainfall intensity. The graph shows the variation of the direction of the flow represented by a positive and negative alternation of peaks.

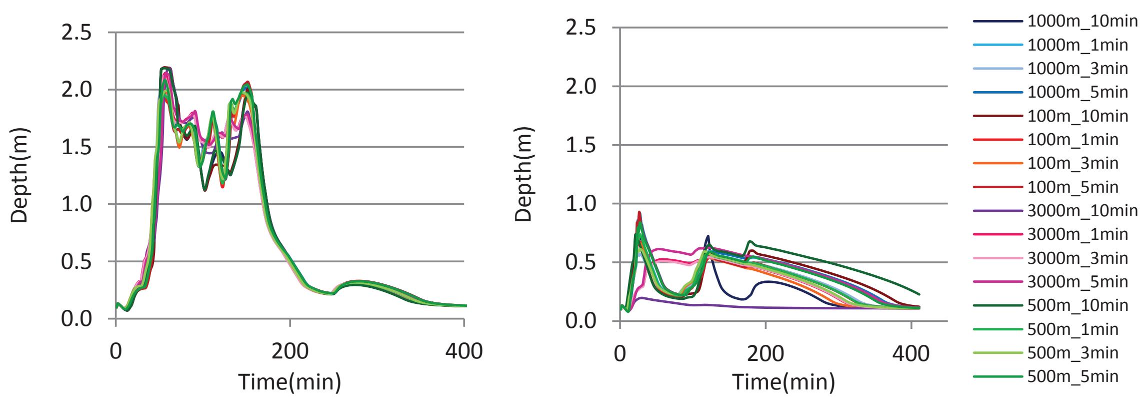

Fig.2: Water depth in a manhole that drains an area of 2ha, during high intensity rainfall event (31.67mm\h, left) and during a low intensity event (10.53 mm\h, right). The graphs show the response of the model to rainfall events measured with different combination of spatial and temporal resolution.

References

Bruni, G., Reinoso, R., van de Giesen, N. C., Clemens, F. H. L. R., and ten Veldhuis, J. A. E.: On the sensitivity of urban hydrodynamic modelling to rainfall spatial and temporal resolution, *Hydrol. Earth Syst. Sci., 19, 691-709, doi:10.5194/hess-19-691-2015, 2015.*

Ochoa-Rodriguez, S., Wang, L. P., Gires, A., Pina R. D., Reinoso Rondinel, R., Bruni, G., Ichiba, A., Gaitan, S., Cristiano, E., van Assel, J., Kroll, S., Murla-Tuyls, D., Schertzer, D., Tchiguirinskaia, I., Onof C., Willems, P., ten Veldhuis J. A.E., Impact of spatial and temporal resolution of rainfall inputs on urban hydrodynamic modelling outputs: a multi-catchment investigation, *Journal of Hydrology, submited.*