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Spatial and temporal resolution effects on urban catchment hydrological response with different imperviousness degrees

Elena Cristiano* , Marie-Claire ten Veldhuis, Nick C.van de Giesen
Water Management Department, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, NL
*corresponding author: E.Cristiano@tudelft.nl

Problem

Fig. 1: Flooding in urban area in Rotterdam(NL)

Pluvial flooding is one of the main problems of urban areas. It is caused by growing of urbanization and by the increase of intense rainfall events. The runoff generated by intense rainfall in an urbanized enviroment is fast and characterized by high spatial variability and short and fast response.

Objective

Fig. 2: X-band dual polarimetric radar installed at the CESAR observatory (NL)

Aiming to better understand the behaviour of the runoff in urban areas, this study investigates the sensitivity of the urban hydrological model to different spatial and temporal high resolution rainfall data. In paticular it will focus on the effects that the imperviousness has on the model.

Conclusions and future work

- Temporal resolution has a bigger influence on the sensitivity of the output of the model then the spatial resolution;
- Catchments with a higher degree of imperviousness are less sensitive to different combination of spatial and temporal resolutions.
- More catchments with different characteristics and more storms have to be considered;
- A theoretical approach can be applied in order to better understand the behaviour of the model.

Methods

We considered:
- Detailed sewer system model of 3 ***districts*** of Rotterdam (NL): Kralingen, Centrum and Spaanse Polder. These catchments have different surface types;
- High resolution rainfall data of 9 ***storms*** measured from the X-band dual polarimetric weather radar of Cabauw. These rainfall events present different charachteristics (length, direction, velocity, ...);
- 16 combinations of ***spatial*** (100m, 500m, 1000m and 3000m) and ***temporal*** (1min, 3min, 5min and 10min) ***resolutions.***

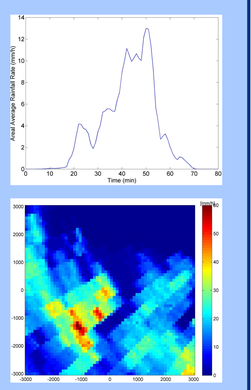

Fig. 2: Areal average storm profile and snapshot image during the peak intensity period of one of the storm studied.

References

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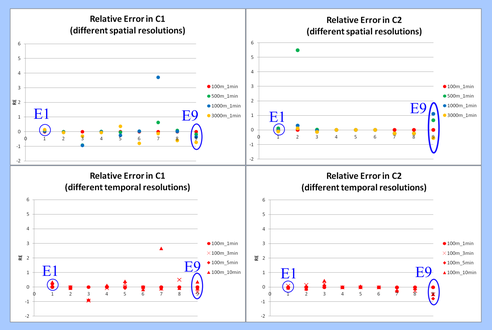
Results

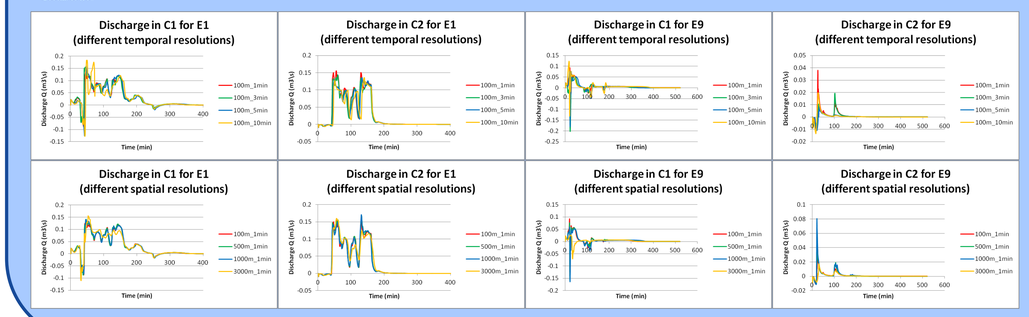
Two small subcatchments (2 ha) with different surface types are studied:
- C1: industrial area situated in the Spaanse Polder district, covered by open flat paved (~45%) and flat roof (~55%);
- C2: residential area in the Centrum district, covered by closed flat paved (~21%), open flat paved (~45%), sloped roof (~23%) and flat roof (~11%).

Relative error RE:

$$RE = \frac{Q_{max_{st}} - Q_{max_{ref}}}{Q_{max_{ref}}}$$

where Q_{maxst} is the flow peak corresponding to a rainfall input of spatial s and temporal t resolution, and $Q_{maxref}$is the reference flow peak corrisponding to the 100m-1min resolution. The relative error RE represents a overstimation (positive values) or an understimation (negative values) of the peak flow Q_{maxref}.





In these graphs the relative error RE is plotted for each rainfall event. In the first two graphs we compare the effects of different spatial resolutions, while in the following graphs the effects of different temporal resolutions are studied. The red dots represent the highest combination of spatial and temporal resolutions correspondig to 100m-1min.

The C2 subcatchment, which presents a lower storage capacity due to the sloped roofs, is less sensitive to the different combinations of resolutions.

It is interesting to notice that for both the catchments the hydrological response is more sensitive to the last three events, which are faster and which require a smaller temporal resolution.

The hydrograph corresponding to different spatial and temporal resolutions is plotted for E1 (where response of the catchments is not very sensitive) and for E9 (where the response of the catchment is more sensitive).