Università degli studi di Napoli Federico II

Scuola Politecnica e delle Scienze di Base

Department of Civil, Architectural & Environmental Engineering

Katholieke Universiteit Leuven

Department of Civil Engineering

MASTER'S THESIS IN ENVIRONMENTAL ENGINEERING

"Spatial analysis of high resolution rainfall data for urban flood application, making use of crowd-sourcing data"

Supervisor:

Ch.mo Prof. Ing. Giuseppe Del Giudice

Co-supervisors:

Ch.mo Prof. Ing. Massimiliano Fabbricino

Prof. Patrick Willems

Candidate:

Salvatore Delle Cave Matr. M67/439

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ABSTRACT

Flooding in urban areas is a phenomenon that occurs when the amount of water falling on the ground exceeds the capacity of the drainage system of the city, and consequently water is discharged into the streets. This cause many problems, such as damages to the buildings and/or public infrastructures, limitations to the flow of traffic and it has indirect impact on economic activities. (T.G. Schmitt, 2004) (Schmitt et al., 2004)

In particular, high intensity and small duration rainfalls are the ones that could cause such types of problems: extreme peak intensities are likely to undermine the sewer system and so causing flooding. The main aim of this thesis is to analyse rainfall data coming from different sources and to evaluate their influence on urban flood modelling results, for a study area located in the city of Antwerp in Belgium. For this purpose, rainfall measurements from two rain gauge networks (namely Waterinfo and Netatmo) and rainfall estimates from a weather radar (provided by the Royal Meteorological Institute of Belgium) are collected and processed.

Particular attention was given to the Netatmo crowdsourced rainfall data, which could give more advantages than the official rainfall data (coming from Waterinfo for the city of Antwerp), due to the high-density coverage they provide. Nevertheless, since they represent an amateur rain gauges network, a quality assessment and control of their data is needed. In this regard, a comparison between the two rain gauges sources was carried out, for 11 selected rainfall events and assuming the Waterinfo data as the 'real' rainfall data. Three statistical parameters were calculated and analysed against the distance between each Waterinfo station, in order to identify the potentially not reliable stations. Then an inter-Netatmo stations approach has been followed to determine whether wide differences were due to the spatial variability of the event or to a failure of the Netatmo rain gauge.

After that, radar data have been analysed: since they cannot properly register the peak intensities, they were corrected by using both Netatmo and Waterinfo rain gauges measurements as reference and two types of correction have been made: a simple mean-field bias correction (MFB) and the singularity-sensitive merging method proposed by (Wang et al., 2015) (SINM).

An analysis between different data was carried out using quantitative comparisons within the study area, for 4 selected rainfall events (the ones which caused floods in the city centre of Antwerp). To further understand how they impact on urban flood simulations, rainfall products obtained from different sources and techniques are used as input in the 1D-2D InfoWorks model available for the city of Antwerp. Flooding maps are produced and compared against flooding record registered by the fire brigade within the period 2015-2016.

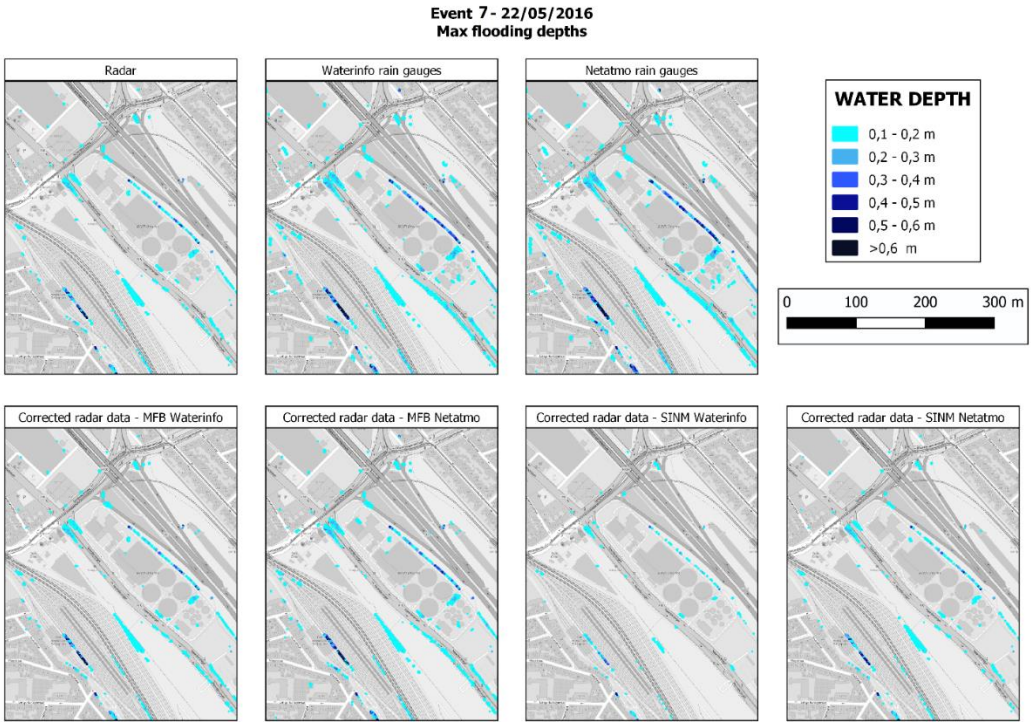

Figure 1 - Flood simulation results for Event 7

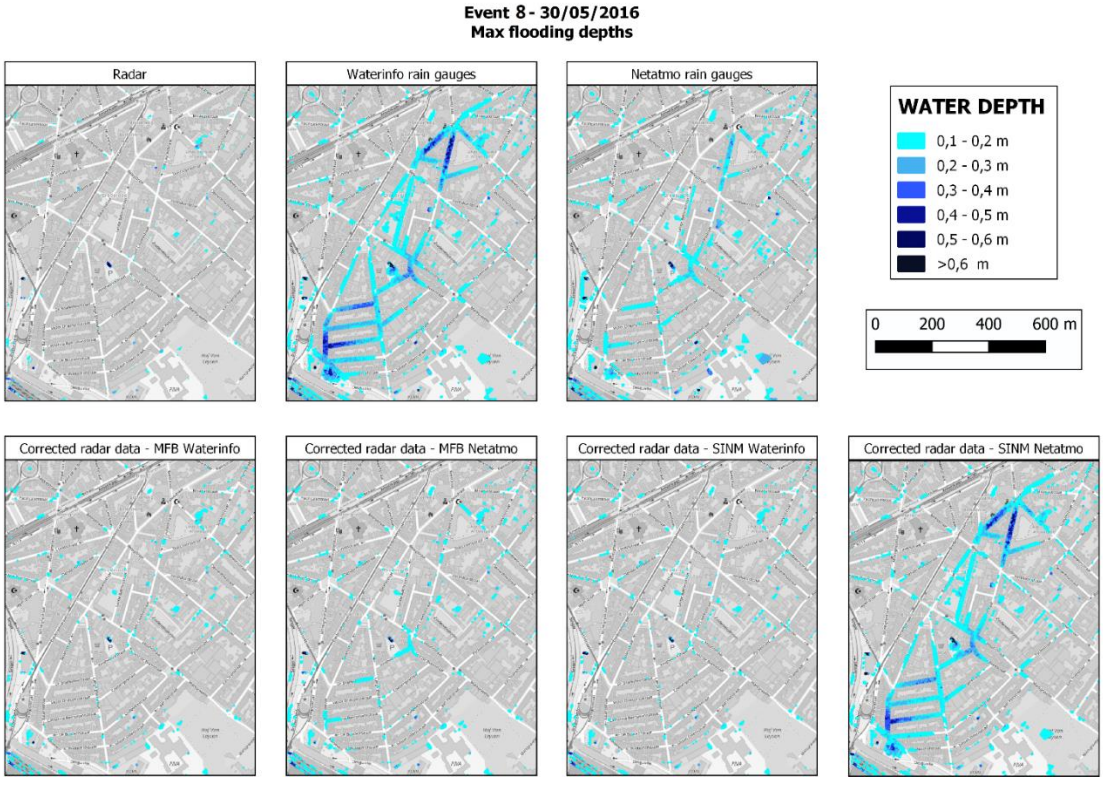

Figure 2 - Flood simulation results for event 8

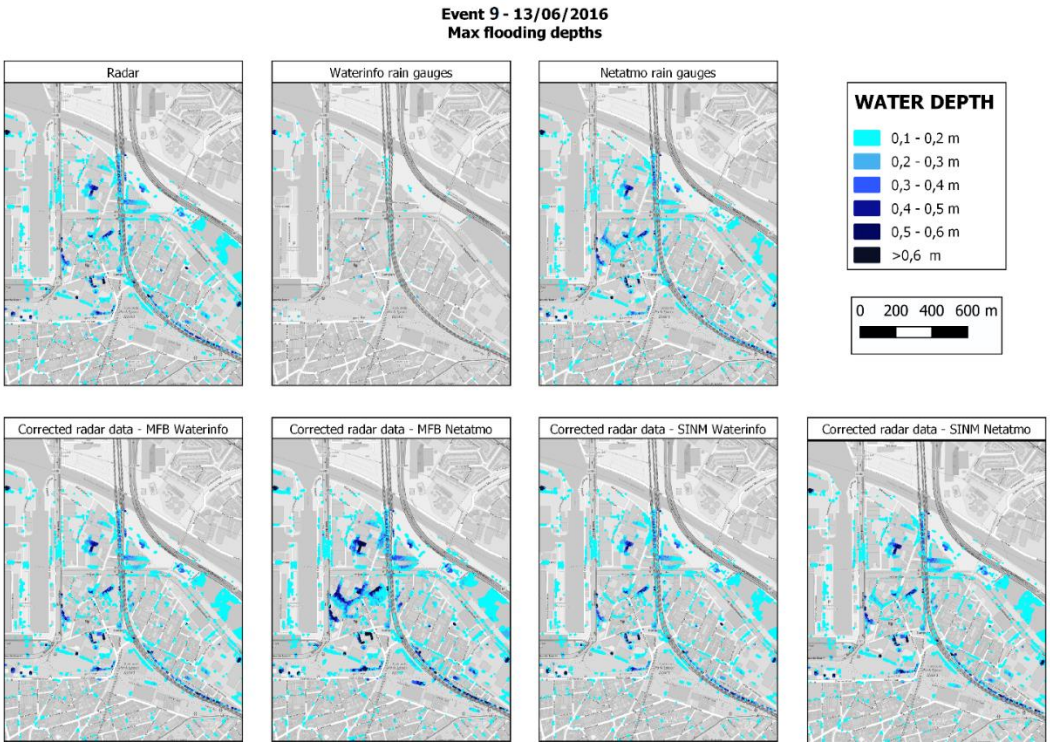

Figure 3 - Flood simulation results for event 9

According to this study, rain gauges alone cannot be used to make flooding predictions. Even though Waterinfo are the official source of radar data, they cannot be representative of the whole catchment because of their low density. On the other hand, Netatmo network has the advantage to be a high density-point field of measurements, thus better explaining the spatial variability of rainfall than Waterinfo. Nevertheless, convective rainfall cells are highly dynamic, thus rain gauges could still miss them.

The Mean Field Bias correction seems to provide good adjustment in terms of peak intensities although they remain far from the ones registered by rain gauges. Moreover, it is pointed out that the quality of the correction is higher when the rain gauges dataset is bigger, due to the averaging process that this technique involves. Sparse rain gauge network (i.e. Waterinfo) may not provide enough information for the correction, while a denser network (i.e. Netatmo) can better capture the variations in rainfall structures. For highly dynamic events, anyway, the MFB could be inadequate for floods predictions, since it poorly improves the radar measurements at peak intensities.

The best performances come from the Singularity Merging correction method. It shows the best performance regarding the rainfall peak intensities. For this reason, the flooding map they produce are representative of the worst scenario in terms of water depths, most of the times. Among all the inputs used for this study they can be considered the most reliable to be used as data to make predictions, since they can both preserve the spatial structure of rainfall and give accurate estimates

for the peak intensities although some cases of overestimation, critical for flooding in urban catchment.

However, it must be kept in mind that all these result are strongly dependent on the particular case study under consideration, which means: set up of rain gauge network, study catchment and selected rainfall events. One important conclusion is that Netatmo network can effectively be useful in matters of flooding, especially at small scale such as urban areas. Their density can be a great advantage to overcome the always-rare distribution of official rain gauges and so give more and more accurate information about peak intensities, the ones that are most important in urban pluvial flooding. Consequently, also the correction techniques using them as reference can produce results which fit the reality in a better way.

Nevertheless, they are not subject to any form of quality control such as calibration and this is the reason why many studies are still going on their quality assessment, and for now, a previous analysis should be done before using the data they provide to the public.