

The use of X-band polarimetric radar to assess the impact of different temporal and spatial resolution on a drainage system in Rotterdam urban area.

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Introduction and description

This study aims to assess the impact of different temporal and spatial rainfall resolutions on the hydrological response of a highly urbanized area. The catchment under study is one of the pilot locations of RainGain Interreg IVB project, which aims at improving fine-scale measurement and prediction of rainfall to enhance urban pluvial flood prediction within cities.

Heavy rain precipitation can cause catastrophic flooding events over urbanized areas. Accurate information about rainfall is needed to be able to mitigate consequent damages. Due to the high percentage of imperviousness and low rate of vegetation interception, the reaction of urban drainage catchments to a storm event is short. Therefore, to describe fast runoff processes and short response times, urban hydrological modelling requires high resolution rainfall data.

Here rainfall from dual polarimetric doppler X-band radar, belonging to the Dutch national meteorological observatory CESAR, is applied to an urban catchment of 3,7 km² that has a combined sewer system with 3062 nodes and 11 external weirs, which serve as outflow. The nodes are inter-connected by 3286 pipes. Among the latter, 4 are pressurized. There are also 2 external pumping stations transporting water to the WWTP and the river. The district belongs to a polder area, i.e. below sea level. For this reason, during heavy rainfall, excess storm water needs to be pumped out in the river system or temporally stored.

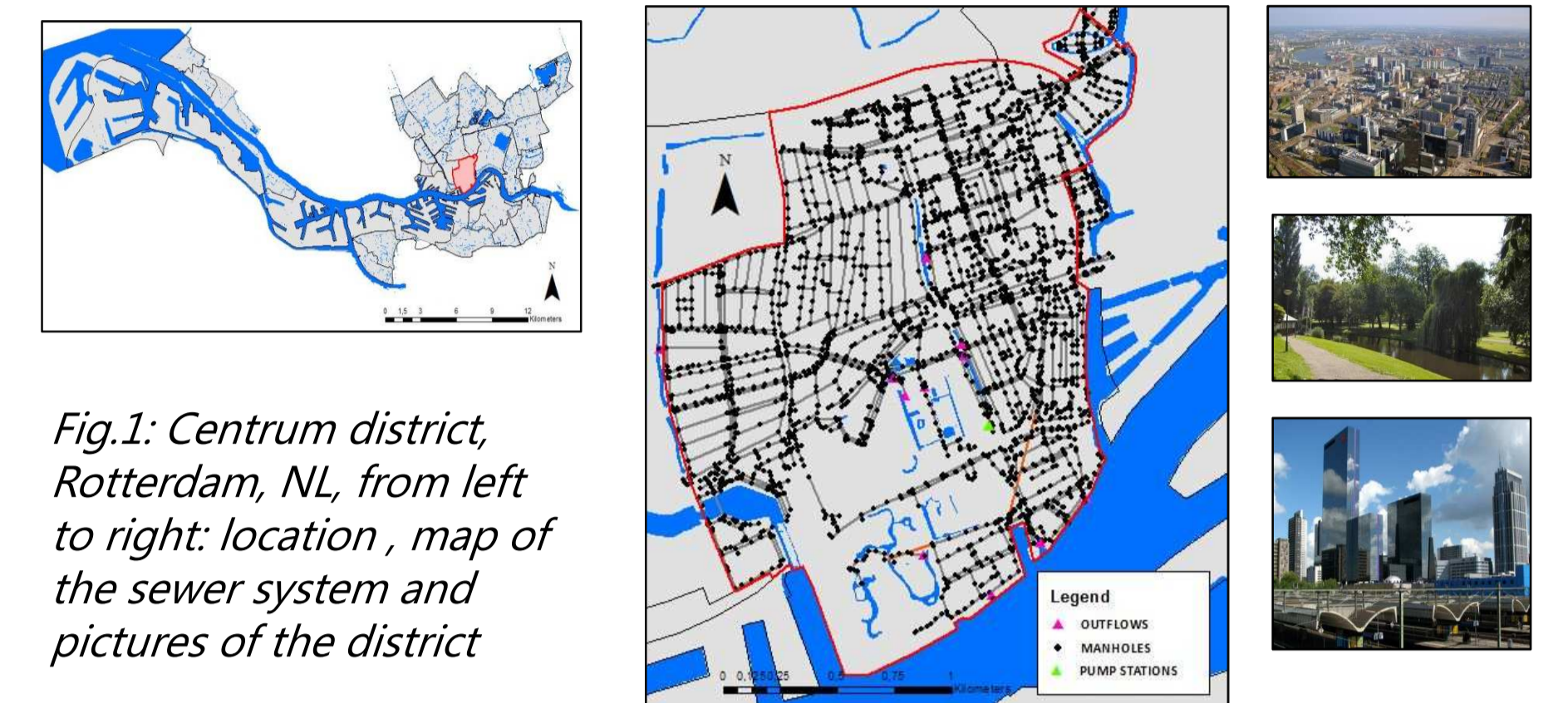


Fig.1: Centrum district, Rotterdam, NL, from left to right: location, map of the sewer system and pictures of the district

Temporal resolution

Rainfall. The storm lasts 1 hour in total and maximum intensities last 5 minutes. 100-m 1-min X-band rain rate estimates are accumulated into 5-min and 10-min data. Peaks result strongly smoothed over the whole area and 1-m resolution is still not enough to track the storm pattern:

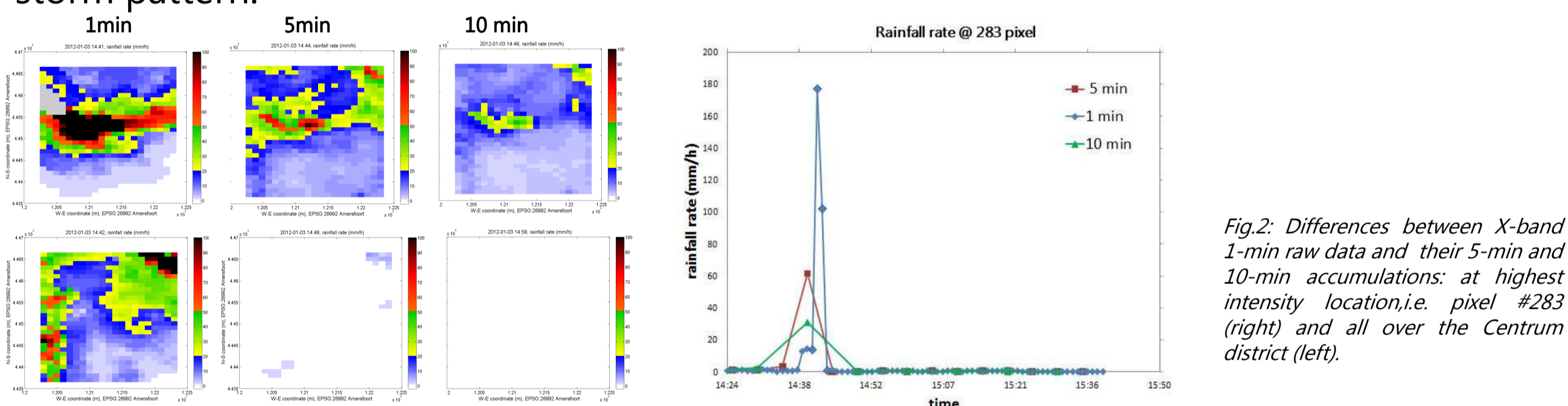


Fig.2: Differences between X-band 1-min raw data and their 5-min and 10-min accumulations: at highest intensity location, i.e. pixel #283 (right) and all over the Centrum district (left).

Spatial resolution

Rainfall. 100 m and 500 m pixel resolution (10-min accumulations) are compared with rainfall uniformly distributed all over the study area, provided by 2 X-band pixels, i.e. virtual rain gauges:

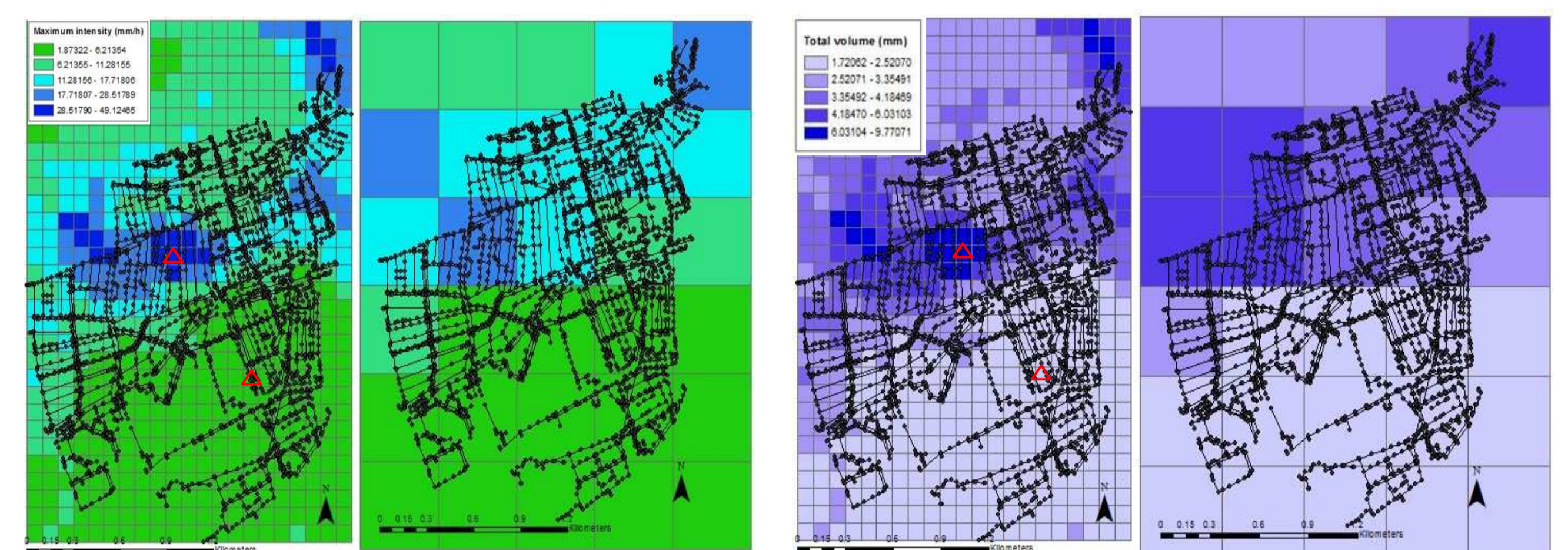


Fig.4: Difference in rainfall spatial resolution: maximum intensity pixel distribution (left) and total volume of the storm (right). Red triangles show the pixel selection for the "virtual rain gauges".

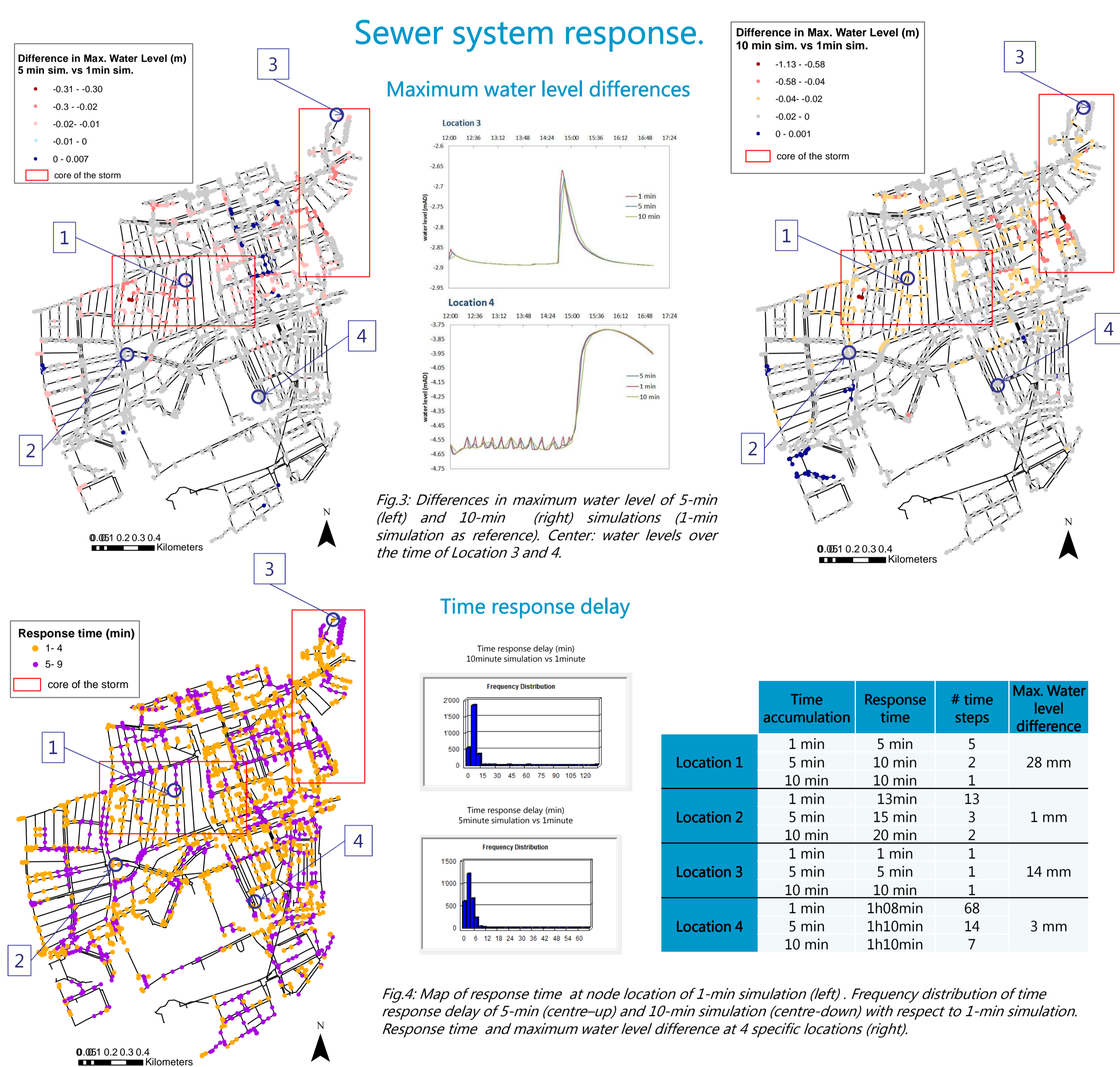
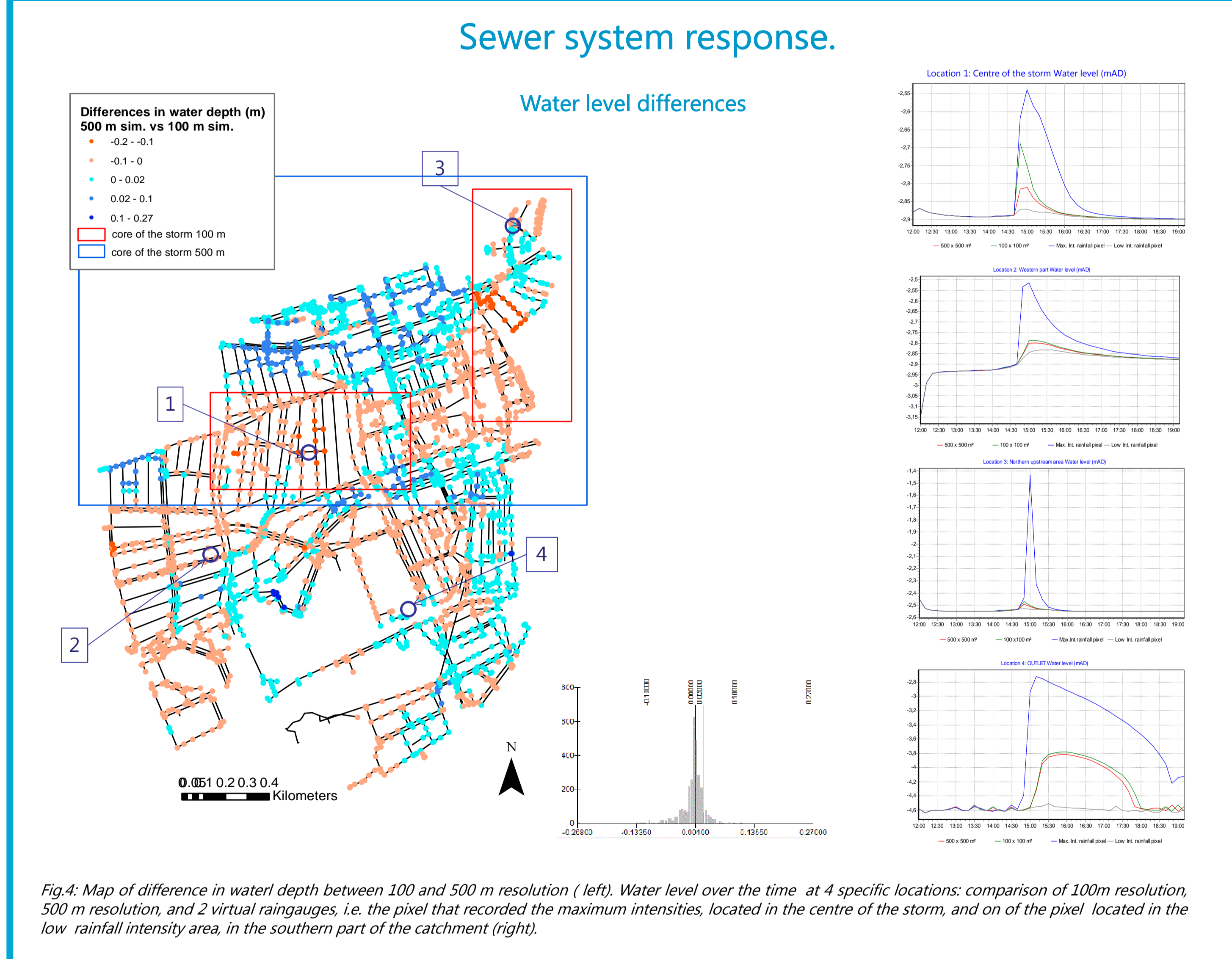


Fig.3: Differences in maximum water level of 5-min (left) and 10-min (right) simulations (1-min simulation as reference). Center: water levels over the time of Location 3 and 4.

Fig.4: Map of difference in water depth between 100 and 500 m resolution (left). Water level over the time at 4 specific locations: comparison of 100m resolution, 500 m resolution, and 2 virtual rain gauges, i.e. the pixel that recorded the maximum intensities, located in the centre of the storm, and on of the pixel located in the low rainfall intensity area, in the southern part of the catchment (right).



Discussion and conclusion

Temporal resolution

- There is no significant difference in water levels when the temporal resolution decreases: only 0,3% of the 3.062 locations show differences greater than 2 cm between 1min and 5 min temporal resolution, and only 1,7% of them show differences greater than 4 cm between 1 min and 10 min temporal resolution. Higher differences in maximum water levels are found in the two areas affected by the convective storm cells.
- Response time: in the 1 min simulation, at 42% of the locations (out of 3062 nodes), the response time is less than 5 minutes and in 72% of the locations is less than 10 minutes. Thus, for most of the locations, the response time cannot be properly assessed by 5 min and 10 min simulations, which become a limitation.
- Difference in rainfall temporal resolution affects the response time in areas where differences in rainfall intensities are higher, i.e. where the rainfall peaks are most smoothed by the decreasing of resolution.

- At the outlet, where the response time is around one hour, due to upstream weir storage, the rainfall temporal resolution effect is smoothed: the outlet is located in a low intensity rainfall area, so the dominant effect is the water routing across the contributing catchment.

Spatial resolution

- The spatial resolution coarsening lead to an extension of the storm area: part of it is affected by higher rain volumes while in the centre of the storm rain volumes result smoothed. The change in rainfall structure and storm size results in differences of water levels: in 70% of locations maximum water level is smaller when coarser rainfall input is used. However, in this particular storm, differences are not significant, i.e. range between -7 cm and 5 cm.
- Higher differences are found comparing results in water levels between distributed rainfall and uniform rainfall provided by the 2 virtual rain gauges. For this reason, under convective local storms conditions, the point information provided by rain gauges is insufficient and lead to over/under-estimations.