CityCAT
Urban Flood Model

urban flood resilience

FACTSHEET

Project area: *Urban flood modelling*
Intended audience: *Researchers, practitioners, general public*

Introduction

A fine resolution, accurate, urban flood model allows the effects of land-use change, climate change and Blue-Green infrastructure (e.g. blue-green roofs, permeable areas, swales, water butts) to be simulated, which can improve urban flood resilience and aid the optimum design of a Blue-Green City.

CityCAT is a state-of-the-art urban flood modelling system that simulates flow pathways, and water depths and velocities for rainfall events. Buildings, impermeable areas and green areas are explicitly represented in the model. Additionally, the model includes the storm sewer network which is fully coupled to the surface flow model.

Practical application of this research:

- Practitioners wishing to assess the impacts of new infrastructure in an urban environment require a tool that enables them to locate appropriate places and designs that minimize local flood issues and importantly assess the potential for enhanced flooding.
- CityCAT is a state-of-the-art modelling system that can simulate flooding in an urban environment.
- Using CityCAT, different infrastructure scenarios can be simulated and the impacts of flooding, with associated monetary costs, can be calculated, enabling the optimum design.

Data Requirements and Model

- The surface elevations (or DEM) are obtained from LIDAR data; typically a 1m or 2m DEM is used to specify the domain as a fine grid.
- The land-use for each grid square is categorized into three types: green areas, buildings and impermeable areas. The data are derived from the UK Ordnance Survey MasterMap data set.
- Green areas allow infiltration, which is calculated using a physically-based equation (Green-Ampt).

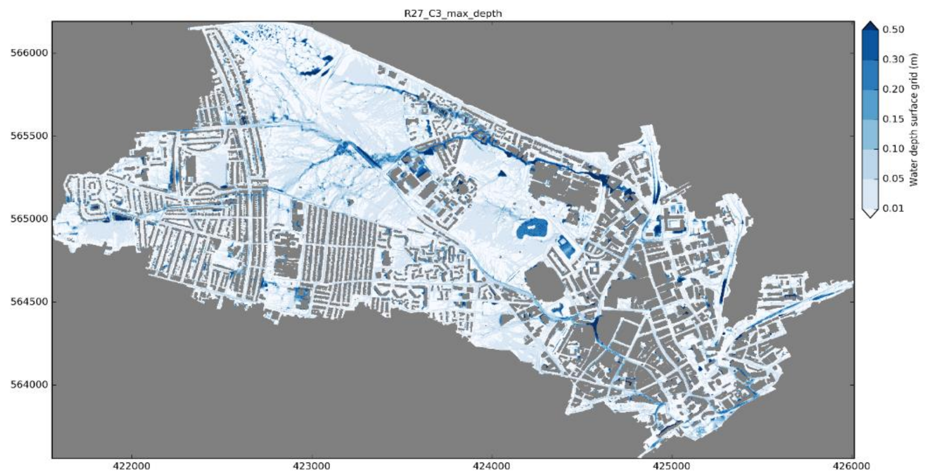

Figure 1: *Maximum Water depths from CityCat simulation of 5.3 km^2 Newcastle Pandon Burn and city centre catchments 1 in 100 year 2 hour event*

- Buildings are removed from the computational grid and rain falling on a building is added to the nearest grid cell.
- Design rainfall events (e.g. the 1 in 100 year, 1 hour event) are usually used, but any rainfall event can be used (including spatially distributed).
- The surface flow model is fully coupled with a storm sewer network model.
- The sewer network model includes the gullies/drains and the sewer pipes and can handle flashy and pressurised flows.
- Infrastructure that can be added includes permeable pavements, green and blue roofs, swales and water butts.

Outputs

- Water depths and velocities (in the x and y directions) are produced at regular timesteps for each grid cell.
- Water depths and any surcharging in the sewer manholes and gullies are also produced.
- The depth of flooding and economic costs of flooded buildings can be calculated.

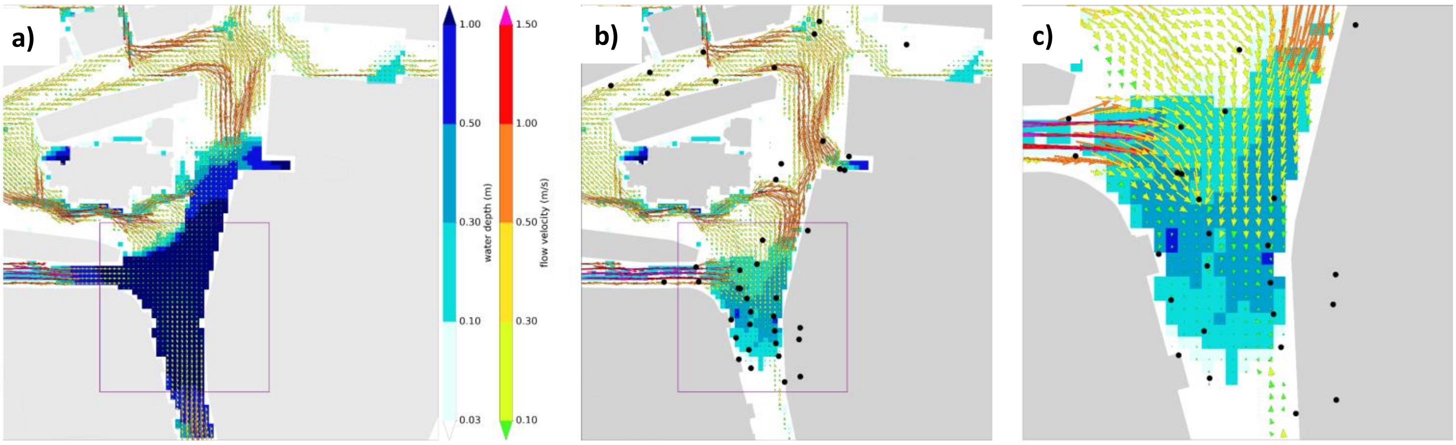

***Figure 2**: Simulated Surface water depths and velocities in Newgate Street, central Newcastle at the end of a 1 in 100 year 2 hour rainfall event. a) with the sewer network not represented, b) with the sewer network included, with the black dots representing the location of the gullies, c) zoomed in section of Newgate street more clearly showing velocities (arrows) and depths (grids).*

Results

- Figure 1 shows a typical flow depth map for a 1 in 100 year 2 hour event in central Newcastle upon Tyne. The dark blue area in the lower right is Newgate Street.
- Figure 2 shows high flood depths and the flow pathways in Newgate Street. The depths are considerably lower, and more realistic, in Figure 2b compared to Figure 2a, when the sewer network is modelled. This can be seen in detail in Figure 2c. This location was badly flooded during the "Toon Monsoon" in June 2012 (Figure 3).

Technical Details

- The simulation of the free surface flow is based on the full 2D shallow water equations.
- The numerical solution is obtained using high-resolution finite volume methods with shock-capturing schemes.
- The 1D sewer pipe network is solved for both free surface and pressurised conditions.
- There is full coupling between the 2D surface model and the 1D pipe network model.
- The architecture of CityCAT is based on the object-oriented approach.

***Figure 3:** Flooding in Newgate Street in central Newcastle during the "Toon Monsoon" (courtesy of Newcastle City Council).*

References

Bertsch, R., Glenis, V., & Kilsby, C. (2017). Urban flood simulation using synthetic storm drain networks. *Water*, *9*(12), 925.

Glenis, V., Kutija, V., & Kilsby, C. G. (2018). A fully hydrodynamic urban flood modelling system representing buildings, green space and interventions. *Environmental Modelling & Software*, *109*, 272-292.

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