Benefits of higher resolution rainfall estimates for urban drainage modelling

by

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And many RainGain partners
• Implementation of hydrodynamic models at pilot locations and evaluation of model structures

• Evaluation of the impact of rainfall input resolution on modelling outputs; impact of model structure (semi- vs fully distributed)

• Investigation of alternatives for local flood forecasting systems
PILOT LOCATIONS

London

Rotterdam

Leuven

Paris

Multi-Hydro

InfoWorks

InfoWorks

SOBEK

CANOE

Parsley Oak Store

Investing in Opportunities

Interreg IVB

This project has received European Regional Development Funding through Interreg IV B.
Model building and analysis tools and recommended practices

Review document on urban pluvial flood models: current theory and practice

- Model inputs and components
- Modelling approaches (semi-distributed, fully-distributed, 1D and 2D models of the urban surface, hybrid models, etc.)
Model building and analysis tools and recommended practices

• Review document on urban pluvial flood models
• Updated documentation and tutorial of the Automatic Overland Flow Delineation (AOFD) tool
• Fractal tools for analysis of urban catchments
• Recommendations for dealing with open channels and other small surface features in urban pluvial flood simulations
• General recommendations for dealing with buildings in 2-dimensional (2D) urban flood simulations

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Impact of spatial and temporal resolution of rainfall inputs on urban hydrological modelling outputs
National Weather Radar  Polarimetric X-band radar
1x1 km², 5-15 min  100x100 km², 1 min

Courtesy: KNMI

Courtesy: H.W.J. Russchenberg
INVESTIGATION: IMPACT OF SPATIAL AND TEMPORAL RESOLUTION OF RAINFALL INPUTS ON OPERATIONAL URBAN HYDRODYNAMIC MODELLING OUTPUTS

Rainfall data:
9 storms recorded by X-band radar
16 spatial-temporal resolutions:
100 m – 3 km & 1 min – 10 min

- **Coarser spatial resolutions** generated through aggregation (i.e. averaging)
- **Coarser temporal resolutions** generated through:
  i. Sampling
  ii. Aggregation

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*This spatial resolution was not considered in the present study*
A methodology for characterising and standardising rainfall inputs and results was devised, thus allowing inter-comparison.

Ochoa-Rodriguez et al. (2015), JoH
Analysis and inter-comparison of results considering:

Storm *spatio-temporal* characteristics: storm range, velocity
Sub-catchment drainage area sizes: 1-25-100-300-500-600 ha

Results:
- Flow peak: relative error
- Hydrograph: $R^2$, regr. coeff. $\beta$
Results: Drainage Area Size  ~ L=100m

- Relative Error Max Flow Peak:
  \[ R_{E_{s,t}} = \frac{Q_{s,t} - Q_{ref}}{Q_{ref}} \]
  \( Q_{ref} \): 100 m, 1 min resolution

For linear regression \( Q_{s,t} \) vs \( Q_{ref} \):
- \( R^2 \): coefficient of determination
- \( \beta \): regression coefficient
In general, coarsening of temporal resolution (by sampling) has stronger influence than coarsening of spatial resolution.
In general, coarsening of temporal resolution (by sampling) has stronger influence than coarsening of spatial resolution.

Spatial resolution: big (and dominant) drop in performance only at 3 km resolution.
Mildly sloping; high density drainage network

Steep slopes; high density drainage network; control structures

Variable slopes; high density drainage network; control structures

Variable slopes; high density drainage network; control structures

Ref 100m-3min 500m-1min 1km-1min 3km-1min

100m-5min 500m-3min 1km-3min 3km-3min

100m-10min 500m-5min 1km-5min 3km-5min

100m-10min 500m-10min 1km-10min 3km-10min
Implications of this study

Required temporal resolution of rainfall data: < 5 min

Spatial resolution ~ 1 km seems sufficient for many urban hydrological applications, except for very small drainage areas (~<1ha)

Spatial resolution ≥ 3 km is insufficient (interpolation of rain gauges!)

Impact of rainfall input resolution depends both upon drainage area and storm characteristics

Interaction between temporal and spatial resolutions is crucial!
More information on “Impact of Spatial and Temporal Resolution of Rainfall Inputs on Urban Hydrodynamic Modelling Outputs”:

Thank you for your attention
SUMMARY & LESSONS LEARNED

- **One size does not fit all!** Type of model depends on:
  - Purpose (CSO reduction? Flood visualisation?)
  - Available computer power
  - Data availability: surface data, sewer data & rainfall data

- Fully-distributed models are generally desirable, particularly when ponding is a relevant flooding mechanism. In fact, current tendency is clearly towards fully distributed models, but:
  - Runtimes are still problematic – option: use of nested / hybrid models
  - Fully distributed models require far more detailed data which is not always available and which is harder to process. Tools to deal with some of these challenges have been developed.

- Strong interaction between temporal and spatial resolution of rainfall inputs

- While temporal resolution has shown to have a stronger effect on hydro results, measuring rainfall at higher temporal resolution can lead to improved accuracy.
Alternatives for local surface water flood forecasting systems

• Evaluation of approaches / system structure

• Technologies for system implementation