Multiple Linked SUDS in hydrological modelling for Urban Drainage and Flood Management

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Drivers of Future Development

- The UN prospects urban growth (UN, 2011)
- IPCC Predicts Rise in Extreme Climate Events (IPCC, 2012)

Objectives:

- Strategies have to be able to perform in anticipation of increasing flood hazard and urban development.
- Draining water in a more natural way using infiltration, retention and storage devices in urban areas.
- Decentralisation of drainage systems.
- Control and manage the exceeding water.
Presented Strategy:

Multiple linked small-scale SUSTainable Drainage Systems (SUDS) and meso-scale retention areas.

Methodology
(Slide 4-7)

• Novel approach which enables the modelling of a large number of spatially distributed measures and exceedance flow control

Application
(Slide 8-13)

• Application for a case study in Hamburg.

Conclusion
(Slide 14)

• Assessment of the potential of the strategy for flood mitigation.
Methodology

Implementation of overlays:
• handling a large number of spatially distributed measures
• Water redistribution function for exceedance flow control

System plan

Overlays form small scale catchments with water retention and redistribution function
Water re-distribution functionality to simulate exceedance flow among measures
Methodology

Implementation of multi-layer systems and drainage layers.

Schematic design of SUDS: green roof (left), swale-filter-drain-system (middle), swale (right) (adopted from Hellmers, 2010)
Implementation in the Integrated Kalypso Modelling Framework for flood risk management

KalypsoHydrology
(data processing to quantify the impacts of projected socio-economic and climate change scenarios and combinations of SUDS with urban retention spaces)

GIS basis data:
- Current Land use
- Soil
- Groundwater
- River network

Urban scenario data:
- Future Urban Development Projections

Overlay data:
- Spatial distribution of elements e.g. SUDS
- Design parameters e.g. materials
- Links among elements

Climate basis Data:
- Precipitation
- Temperature
- Evaporation

Climate scenario data:
- Climate Model Simulations (e.g. of REMO, CLM)
- IPCC Scenarios (e.g. A1B, A2, B1)

Longterm Water Balance Simulation

Open Channel Flood Peak Simulation

Kalypso WSPM and Kalypso 1D/2D

Data:
- River network/profiles
- Flood peak discharges

Hydraulic surface water profile simulations

Kalypso Flood

Data:
- Digital terrain data
  - 1D or 2D surface water simulations

Flow depth and inundated areas

Overlay Elements and Model Net Computation

Drainage strands and drainage nodes

Further Information: Kurzbach et. al., 2013: Poster Session A2 on Friday 6th September 2013
Wandse catchment in Hamburg
Wandse catchment in Hamburg

Wandse river: 21.5km

Wandse catchment: 88km²
# Urban Growth Scenarios for Hamburg (2050) and Adaptation Strategies

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Urban Growth</th>
<th>Adaptation Strategy</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Decentralisation: Decrease in population in the inner city.</td>
<td>No financial support for adaptation</td>
<td>No urban growth. No demolition. No adaption strategy implemented.</td>
</tr>
<tr>
<td>S2</td>
<td>Increase of population in the inner city. New buildings and enlargement of the Infrastructure.</td>
<td>Some financial support for adaptation measures</td>
<td>Increase of impervious areas. Increase of stress on the drainage systems.</td>
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<tr>
<td>S3</td>
<td>Increase of population in the inner city. → Buildings with additional storeys.</td>
<td>High financial support for adaptation measures</td>
<td>Less increase of impervious areas. Good implementation of SUDS.</td>
</tr>
</tbody>
</table>

Scenario S3: Multiple linked SUDS

• **Small-scale SUDS:**
  - Green roofs linked with swales
  - Sealed areas drained by swales / filter-drain systems

• **Meso-scale multipurpose spaces:**
  - Exceedance flow retained in multi-purpose spaces
Application

Climate Change Impacts (2036 – 2065)

Scenarios: +20%; +10% and 0%

- High increase of flood peak discharge (+20%)
- Moderate increase of flood peak discharge (+10%)
- No climate change impact

Data Source: regional climate model REMO [Jacob et al., 2005 and 2009]
Three Urban Growth Scenarios

Three Climate Change Impact Scenarios

Suburban Area

Urban – suburban Area

Urban Area
Map of Scenario S3

Legend
- Overlay Polygons
- River Strands
- Sub-catchments

Flood Peak Discharge [m³/s]
- actual [m³/s]
- climate change +10% [m³/s]
- climate change +0% [m³/s]
- climate change +20% [m³/s]
Application

Urban Area | Urban Suburban Area | Suburban Area
---|---|---
S1
S2
S3

Legend
- Green: less flooding
- Red: increased flooding

Reference Flood Event $T = 100$
Waterlevel
- $< 0.01m$
- $0.01m - 0.50m$
- $0.50m - 1.00m$
- $1.00m - 1.50m$
- $1.50m - 2.00m$
- $2.00m - 2.50m$
- $2.50m - 3.00m$
- $3.00m - 3.50m$

(+ 20% Flood Peak Increase Scenario)
Conclusion / Outlook

• Novel approach enables the modelling of a water re-distribution functionality to simulate exceedance flow control.

• It supports the simulation of a large number of spatially distributed measures.

• It enables a detailed simulation of the water retention and hydrological processes in SUDS.

• It is integrated in the Kalypso Modelling Framework for flood risk management.

• The results of the application study in Hamburg showed a potential mitigation efficiency for multiple linked SUDS. Further Studies are required.


Thank you for your attention

Any questions?

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