Urbanization versus climate change: impact analysis on the river hydrology of the Grote Nete catchment in Belgium

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Introduction

• Climate change causes significant change in rainfall patterns and temperature
  – Impact on urban hydrology?

• Urbanization significantly impacts flow regimes of river systems
  – Pressure of urbanization on the river hydrology can be increased due to climate change as some climate change models predict more intense summer storms

• Quantification requires simulation long time series to account for interaction between both systems (river and sewer systems)
Methodology

- Hydrological rainfall runoff model
  - VHM

  Rainfall input $x$

  $X_g = (1-f_u-f_o-f_i) \cdot x$

  $X_u = f_u \cdot x$

  $X_o = f_o \cdot x$

  $X_i = f_i \cdot x$

  Time variable $\Delta$: distributing valve (dependent on $u$)

  Evapotranspiration $e_a$

  Soil moisture storage $u$

  $X_g = (1-f_u-f_o-f_i) \cdot x$

  $X_u = f_u \cdot x$

  $X_o = f_o \cdot x$

  $X_i = f_i \cdot x$

  Overland flow

  Interflow

  Baseflow

  Total rainfall runoff
Methodology

• Hydraulic river model
  – MIKE11 (DHI)
  – 138km of rivers divided over 23 branches modelled in detail
  – Cross-section information is included every 50 meters on average, except when there are structures that require a smaller space resolution
  – $\Delta t = 30$ second
Methodology

• Urban contributions to river flow
  – WWTP and CSO discharges
  – InfoWorks-CS model developed by the Flemish water company Aquafin NV
  – Modelled time series (Δt 10 min) of urban fluxes that are situated within the catchment are input as point sources in the river model
Methodology

• Climate change
  – CCI-HYDR Perturbation Tool
    • Quantile perturbation method
    • Delta-changes as a continuous function of return period at a daily time scale, for each month different set of perturbation factors are determined
      – for rainfall: both delta-changes to the number of wet days and to the intensity of these wet days
  – Generate perturbed time series for both the rainfall and daily evapotranspiration time series for the projected climate around the 2080s (2071-2100)
    • Rerun rainfall runoff model and sewer model to know modified upstream, lateral and point inflows of the hydraulic river model
  – Four different scenarios
    • high summer
    • high winter
    • mean
    • low
Methodology

- Extreme value analysis
  - Peak-Over-Threshold (POT) to select nearly independent events
  - Generalized Pareto Distribution

\[
G(x) = \begin{cases} 
1 - \left(1 + \gamma \frac{x - x_t}{\beta} \right)^{-\frac{1}{\gamma}} & \gamma \neq 0 \\
1 - \exp\left(-\left(\frac{x - x_t}{\beta}\right)^\tau\right) & \gamma = 0 
\end{cases}
\]

- From the distribution of the extremes, the return period for different events can be calculated

\[
T(x) = \frac{n}{t} \frac{1}{1 - G(x)}
\]
Results and discussion

Current Climate conditions

- with urban fluxes
- without urban fluxes

Low scenario

Mean scenario

High summer scenario

High winter scenario
Results and discussion
Results and discussion

- Projected peak flows for a return period of 10 years
  - impact of urbanization
  - impact of climate change when including urban fluxes
Conclusion

- Impact climate change under the urbanized condition (-14% to +45%) same order of magnitude as impact urbanization (+5% to +20%)
- Different climate change scenarios do not change the impact of urbanization much
  - Exception!
    - High summer scenario: impact of urbanization on the river system increases from 8% to 20%
    - Only found when analysing difference in extreme value distribution, average increase does remain constant for all scenario’s!
Thank you for your attention!

Questions?