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ICUD-0420 Testing high resolution synthetic rainfall time series representing current and future climates on CSO and other indicators

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Summary

Combined sewer systems have a long technical lifetime, thus climate change must be taken into consideration when designing new CSO structures, basins, and pipe system enhancements. At the same time, the performance is highly dependent on antecedent conditions in the sewer system and is therefore best modelled using LTS. In the present study, we calculate indicators related to CSO statistics using synthetic time series created with different methodologies for both present and future climatic conditions. The methodology for synthetic rainfall generation influences the obtained results along with the physical properties of the catchment and the expectations to climate change.

Keywords

long term simulations, LTS, CSO, climate change, combined sewer overflow, rainfall generator

Introduction

The preliminary dimensions of urban drainage systems are often determined using Chicago Design Storms or similar techniques for sufficiently rare events. This approach is inadequate for assessment of indicators with relatively high frequency of occurrence (e.g. return periods below 0.1 - 0.3 years), especially when analyzing large systems with big volumes and/or Real Time Control installations and is furthermore sensitive to the underlying definition of precipitation events. Therefore Long Term Simulations (LTS) are recommended in these situations (Arnbjerg-Nielsen et al., 2013). Previously, LTS were performed with historical rain series as input. We now know, however, that rainfall patterns are changing. Therefore it makes little sense to use historical rain series to design a system that will last for many decades into the future. The current work investigates how rainfall generators can be used to provide the necessary rainfall input for sound dimensioning taken climate change into account when using LTS. The rainfall generators have previously been validated against Intensity-Duration-Frequency statistics so the focus of the study is on obtaining results from more complicated indicators.

Methods and Materials

We create synthetic rainfall time series for Danish conditions using three different techniques: A Random Parameter Bartlett–Lewis point process model supplemented by a random cascade to reach minute-level temporal resolution (Onof and Arnbjerg, 2009); a Spatial Neyman-Scott Pulse Process Model at hourly temporal resolution without further downscaling (Sørup et al., 2016a); and an empirical perturbation scheme based on a Markov classification and nonlinear scaling between Markov classes (Sørup et al., 2017). For all methodologies, we create rainfall time series for both present and future climate conditions. Further, we compare the ability of the different techniques to reproduce common urban hydrological relevant rainfall statistics.

LTS are simulated with the different rainfall time series as input for Danish catchments having different physical properties from “very flat” to “rather steep”. The present day simulations are measured against results based on LTS simulation with historical observational data regarding 1) numbers of CSOs, 2) volume of CSOs 3) design of detention volumes, and 4) percentage of full pipes in critical situation. The relative effect of climate change on these is then calculated based on the difference between the LTS results from future synthetic rainfall time series and present day synthetic rainfall time series.

Results and Discussion

Results show that the different methodologies for creating synthetic rainfall time series provide time series with very different statistical behavior. Some of these differences can be explained from differences in what is expected from climate change and how this is included in the different methodologies. Others can be explained by the fundamental differences between the models e.g. spatial vs. point model, daily vs. hourly vs. event based temporal resolution, and whether the focus of the model is to reproduce extremes or means.

The dissimilarities between the different synthetic time series are also reflected in the LTS results. The impact of the number of CSOs and other indicators are linked to the physical properties of the catchment and possible explanations of the differences are discussed.

Conclusions

Synthetic rainfall time series are an important tool for evaluation of urban hydrological infrastructure depending on more frequent events and the event chronology. How to generate the synthetic rainfall time series will influence the results and a thorough assessment of this influence has to be made on a catchment scale as the catchments physical properties are of equal importance.

References

Arnbjerg-Nielsen, K., Willems, P., Olsson, J., Beecham, S., Pathirana, A., Gregersen, I. B., Madsen, H., & Nguyen, V.-T. V. (2013). Impacts of climate change on rainfall extremes and urban drainage systems: A review. Water Science and Technology, 68(1), 16–28. doi:10.2166/wst.2013.251

Onof, C., & Arnbjerg-Nielsen, K. (2009). Quantification of anticipated future changes in high resolution design rainfall for urban areas. Atmospheric Research, 92(3), 350–363. doi:10.1016/j.atmosres.2009.01.014

Sørup, H. J. D., Christensen, O. B., Arnbjerg-Nielsen, K., & Mikkelsen, P. S. (2016). Downscaling future precipitation extremes to urban hydrology scales using a spatio-temporal Neyman–Scott weather generator. Hydrology and Earth System Sciences, 20(4), 1387–1403. doi:10.5194/hess-20-1387-2016

Sørup, H. J. D., Georgiadis, S., Gregersen, I. B., & Arnbjerg-Nielsen, K. (2017). Formulating and testing a method for perturbing precipitation time series to reflect anticipated climatic changes, Hydrology and Earth System Sciences, doi: 10.5194/hess-21-345-2017