ELSEVIER

Atmospheric Research 77 (2005) 4–17

ATMOSPHERIC RESEARCH

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Selection of regional historical rainfall time series as input to urban drainage simulations at ungauged locations

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Received 13 April 2004; received in revised form 15 October 2004; accepted 15 October 2004

Abstract

It has become established practice during the past 20 years to use high-resolution historical rainfall time series as input to hydrological model packages for detailed simulation of urban drainage systems. However, sufficiently long rain series are rarely available from the exact catchment in question and simulations are hence often based on available rain series from other locations. Extreme rainfall properties of importance to the performance of urban storm drainage systems vary significantly even in regions with only minor physiographic differences. Part of this variation can be explained by regional variations of the mean annual rainfall and the remaining statistical residue can be interpreted as statistical uncertainty.

In Denmark, more than 75 high-resolution rain gauges are installed across a total area of 43,000 m. About 40 gauges had sufficiently long records to be included in a comprehensive national investigation where newly developed statistical regionalisation procedures were used to model the regional variation of extreme rainfalls. On this basis, a spreadsheet model was made available for estimation of extreme design rainfalls and the associated uncertainty at any location in the country. Statistics were furthermore computed to classify historical rainfall time series according to the developed regional model, and this makes it possible to assess the

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0169-8095/$ - see front matter
doi:10.1016/j.atmosres.2004.10.016

uncertainty related with using different historical rain series for simulations at ungauged locations.

This research indicates that use of historical point rainfall data at ungauged locations introduces a significant uncertainty that is largely overlooked in today's practice. The engineering recommendation is to select historical rain series based on an evaluation of the local physiographic characteristics (e.g., the mean annual rainfall) and a (pre-defined) desired safety level of the simulations.

Keywords: Rainfall; Model-input; Regional model; Local data; Urban drainage; Uncertainty

1. Introduction

Today, it is established practice to use high-resolution historical rain series as input to hydrological model packages for detailed simulation of urban drainage systems. However, sufficiently long rain series are rarely available from the exact catchment in question and simulations are hence often based on available rain series from other locations. Selecting proper rainfall time series as input to simulations remains one of the main problems of practical concern in hydrological modelling (e.g., Einfalt et al., 1998).

In some cases, regional rain gauge networks are available and historical rain series are selected based on some interpretation of the variation of rainfall patterns between the gauges. In other cases, only data with a too low temporal resolution is available, or rain data is not available at all. In every case, measured rain series may misrepresent the actual rainfall field either due to measurement errors or due to micro-climatic conditions that lead to bias of the data. Spatial variations in heterogeneous (e.g., mountainous) regions have always been recognised whereas variations in more homogeneous regions have more or less been neglected. Experience from recent Danish research however indicates that extreme rainfall properties of importance to the performance of urban drainage systems vary significantly even in regions with only minor physiographic differences (Mikkelsen and Harremoës, 1993; Madsen et al., 1994; Mikkelsen et al., 1997). Similar conclusions have been obtained in other, relatively homogenous, regions around the world; in the analysis of extreme rainfalls in Washington State in the US (Shaefer, 1990), Canada (Adamowski et al., 1996) and Denmark (Madsen et al., 1998, 2002), it was found that certain statistical rainfall characteristics vary systematically with the mean annual rainfall (MAR) and, hence, this parameter seems to be of crucial importance when identifying representative rainfall input.

The present paper outlines the regional analyses carried out recently in Denmark and reports how this has been used to work out a systematic methodology for selecting historical rainfall series for simulation of urban drainage problems at ungauged locations. Focus is on cases where one single rainfall series is used as input to simulations, i.e., where catchments are sufficiently small to neglect spatial variations within the catchment.