ELSEVIER

Atmospheric Research 77 (2005) 48–59

ATMOSPHERIC RESEARCH

www.elsevier.com/locate/atmos

# Areal rainfall correction coefficients for small urban catchments

G. Vaes*, P. Willems, J. Berlamont

*Hydraulics Laboratory, University of Leuven, Kasteelpark Arenberg 40, B-3001 Heverlee, Belgium*

Received 5 April 2004; received in revised form 18 August 2004; accepted 15 October 2004

**Abstract**

The spatial rainfall variability can have a large effect on the prediction of discharges in urban drainage systems. Areal rainfall correction coefficients are often used to cope with this problem. This paper makes a clear distinction between two types of areal correction coefficients: one for correction of historical data at given time moments and one for rainfall at given return period levels. The first type can be used within applications of calibration of models of urban drainage systems, while the second type is needed for design purposes. The second type is most often found in the literature and referred to as the "areal reduction factors". This paper shows that for small catchment areas and limited rainfall intensities, they also may reflect an increase and not always a reduction. Therefore, they are called more generally "areal correction coefficients" in this paper. Both types of coefficients were derived for the Flanders region in Belgium. They were based on simulations with a spatial rainfall generator. The areal correction coefficients were considered dependent on the size of the catchment, the rainfall aggregation level, and the rainfall intensity (linked to the return period through IDF-relationships). The dependencies in time and space make a correct application of correction coefficients to the combined hydrologic–hydrodynamic modelling of urban drainage systems and the design of these systems not obvious, as pointed out by the paper.


*Keywords:* Areal correction coefficient; Design; Point measurement; Rainfall; Spatial variability

* Corresponding author. Tel.: +32 16 24 05 01; fax: +32 16 24 05 09.
*E-mail address:* guido.vaes@hydroscan.be (G. Vaes).

0169-8095/$ - see front matter 
doi:10.1016/j.atmosres.2004.10.015

## 1. Introduction

Rainfall input for hydrologic modelling purposes is most frequently originating from point rainfall measurement stations. In the models, the point rainfall is assumed uniformly distributed over the entire catchment or, at least, over parts of the catchment. The spatial rainfall variability can, however, be large, which can lead to significant errors in the input volumes for the hydrologic models. This has been shown before by, e.g. Schilling (1984) and Einfalt et al. (1998). In this paper, the focus is on applications with mathematical models for urban drainage systems. This means that the rainfall input is investigated for catchments with small spatial scales.

Different effects are playing a role in the spatial variability of rainfall over the catchments covered by urban drainage systems. The rainfall intensity varies strongly within a storm period. A single storm cell has typically a Gaussian variation with a median value for the standard deviation of about 2.5 km (Fig. 1; Luyckx et al., 1998). For catchments with a diameter of several kilometers, this can lead to significant differences in rainfall volume as compared with uniformly distributed rainfall. By the same reason, rain gauge networks will rarely observe the peak intensity of a storm. The spatial density of the rain gauges is indeed in most practical cases smaller than the storm cell diameter.

Areal correction factors have been used for many decades to account for the effect of the difference between point rainfall and catchment-averaged rainfall volumes (e.g. ASCE, 1969). They are often based on the analysis of the spatial rainfall variation around the center of the storm. In Belgium, for instance, the areal reduction coefficient of Frühling is being used for almost 100 years (Mennes, 1910). This areal reduction coefficient is based on three measurement locations, situated in Breslau (actually Wroclaw, Poland). This is relatively far from Belgium (approximately 1000 km), which could question the validity of the use of these observations. Frühling found out that the rainfall intensity at 3 km from the center of the storm was halved and was negligible at 12 km and proposed a parabolic spatial distribution for the spatial rainfall variation. In Fig. 1, this areal reduction factor is

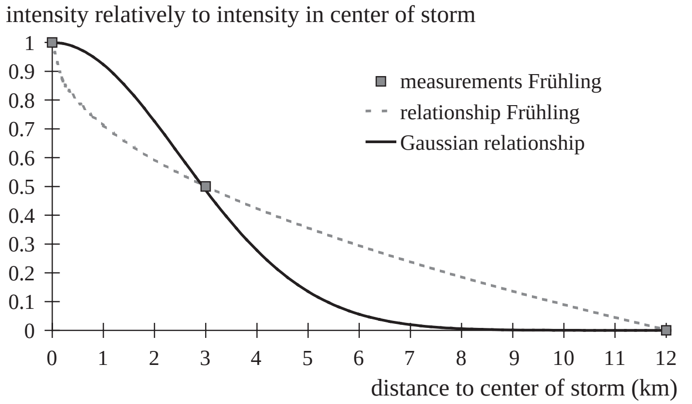


Fig. 1. Comparison of rainfall intensity observations at different distances from the center of the storm with the areal reduction factor proposed by Frühling (Mennes, 1910) and the Gaussian model for the rain cell (Luyckx et al., 1998).