Author: Migone

Chiavari (Genoa - Italy)
The 11 November 1935 flood

DESIGN RAINFALL AND THE ACCURACY OF RAIN INTENSITY RECORDS

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The problem in a first glance…

The issue of quantifying the influence of measurement errors on the reliability of **extreme rainfall statistics** used to derive design rainfall **for urban hydrology applications** is here addressed. The uncertainty derives from systematic mechanical errors affecting the most popular rain intensity measurement instrument, namely the tipping-bucket rain-gauge, and strongly depends on the measured rainfall intensity. In particular, a **systematic underestimation of high rainfall intensities** is observed.

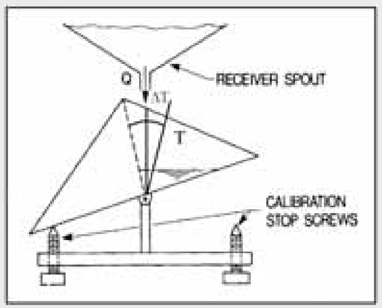
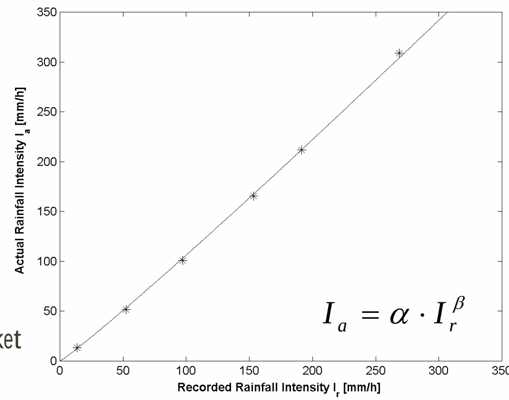


Figure 1: The tipping-bucket mechanism (after Marsalek, 1981)

These are usually recorded over short durations in time, so that suitable corrections strongly depend on the time resolution of recorded data. In this work, we propose a simple **procedure for the correction of low resolution data after disaggregation** at a finer scale so that evaluation of the influence of systematic errors on the statistics of rainfall extremes becomes possible.

Figure 2 Dynamical calibration curve for the tipping-bucket rain gauge of DIAM - University of Genoa



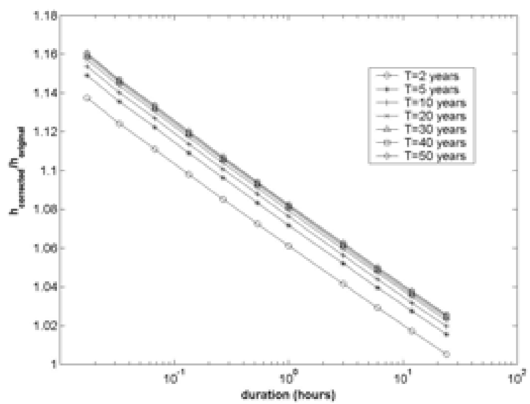


Figure 3 Synthetic representation of the "gain" obtained after direct correction on the high resolution data set from the DIAM station

1 Storm water control and design rainfall estimation

Efficient storm water control in the urban environment is generally obtained by proper dimensioning of the drainage system (including pipes, culverts, storage tanks, etc.) according to a suitable design rainfall event with a specified non-exceedance probability F. In the usual design practice this is also expressed by means of the related return period T = 1/(1-F)

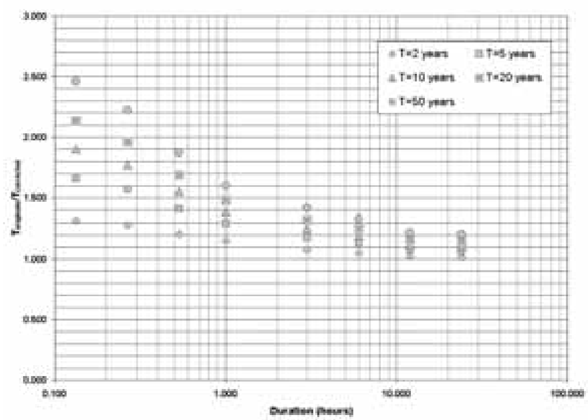
2 The influence of mechanical errors on rainfall extremes statistics: direct and indirect correction

Correct estimation of the return period of a given rain event is based on the prolonged and accurate measurement of rain data. A correction procedure for rain intensity data sets is proposed in this paper based on the dynamic calibration of the gauge at both fine and coarse resolution, either in direct form or after proper downscaling of the available figures.

3 Direct correction

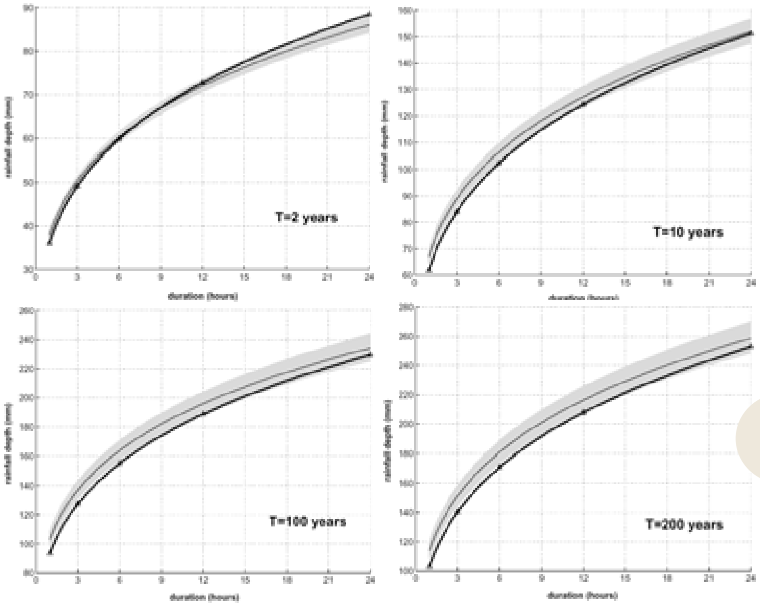
In case the rain series is available at fine resolution in time (e.g. in the order of 1 to 10 minutes) direct correction is possible by simply modifying recorded values at each single time step. Correction is obtained by using the equation of **Figure 2**, with the actual intensity being the unknown variable. The specific correction parameters α **and** β **must be preliminarily available for the instrument in hand**, as derived from suitable dynamic calibration of the gauge.

Figure 4 The influence of systematic mechanical errors on the assessment of the return period for the DIAM station



4 Correction after downscaling

The most common resolution for historic rain records of sufficient length to allow suitable statistical analysis is the hourly scale. This is also the case for the data set obtained from the Meteorological Observatory “Andrea Bianchi” of Chiavari over the period 1961-2000. Indeed, the apparent rainfall intensity decreases with increasing aggregation of the rain depth increments in time, so that correction would be applied on artificially lower rain rate figures that do not correspond to the original rain rates actually recorded by the instrument. On the contrary the error affects the originally recorded rain rates, thus higher values than those resulting from aggregation at the hourly scale, and direct correction of such information would inevitably result in large underestimation of the biases involved. The high resolution pattern of rain intensity in time is therefore unknown and correction can not be directly performed.



Reconstruction of the original variability at sub-hourly scales is therefore required, at least down to a resolution in the order of one to five minutes, since at lower scales sampling errors may become also relevant. Appropriate downscaling methodologies allow performing this exercise in a statistical sense, i.e. by generating a set of possible scenarios of the inner rainfall structure that are compatible with the recorded pattern at the coarser (hourly) scale. Once small scale data are available for each of the generated scenarios, direct correction is possible and data are re-aggregated at the original resolution in order to allow comparison with the original data set. Ensemble statistics for the whole set of corrected time series may finally provide the required parameters and their dispersion characteristics.

The adopted disaggregation procedure 5

The downscaling procedure used in this work is a multiplicative random cascade of branching number two with exact conservation of mass. A detailed description of the method and its theoretical background is provided e.g. by Güntner *et al*. (2001), Menabde *et al*. (1997) and Olsson (1998).

6 A few results

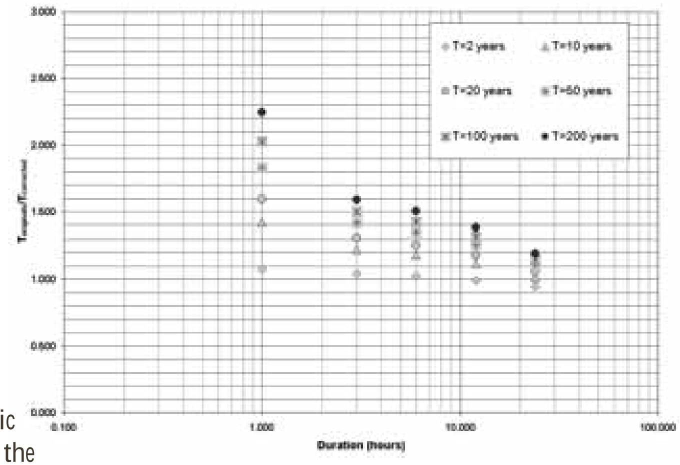


Figure 5 The influence of systematic mechanical errors on the assessment of the return period for the Chiavari station

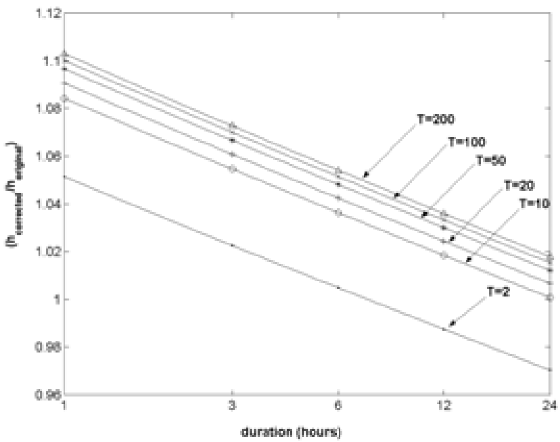


Figure 6 Synthetic representation of the “gain” obtained after correction of the high resolution realisations obtained from downscaling hourly records from the Chiavari station

Acknowledgements

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Chiavari (Genoa - Italy)
The 24 November 2003 flood