03 Towards continuous rainfall simulation for design

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MAXIMUM LIKELIHOOD ESTIMATION OF THE SEASONAL NEYMAN-SCOTT MODEL FOR RAINFALL

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Continuous simulation of rainfall data is often performed in hydrology, usually by applying cluster models, which have been shown to satisfactorily fit the main statistics of rainfall data observed on a wide range of time scales. Among the cluster models, the Neyman-Scott rectangular pluses model is widely applied, both in its univariate and multivariate forms. The estimation of the model parameters has been traditionally carried out by using the method of moments, because maximum likelihood approaches were found to be not easily applicable to this kind of models. Recently, an approximated maximum likelihood estimator for univariate cluster models has been proposed. It makes use of the Whittle's approximation to the Gaussian maximum likelihood function. This approach, which provides consistent and normally distributed estimates, has performed satisfactorily well when applied to some rainfall data observed in Great Britain. We propose here an extension of this method for estimating seasonal Neyman-Scott models, whose parameters are varying with the season. The seasonal spectral density of the data is estimated by taking the Fast Fourier Transform of the respective seasonal sample autocorrelation function. The procedure has been applied for fitting some daily rainfall data observed in different seasons in Italy.

REGIONALISATION OF THE PARAMETERS OF AN MCMC BASED MODEL FOR THE SIMULATION OF PRECIPITATION SERIES

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Precipitation data in high temporal resolution are required for design purposes in many hydrological applications. Measured data are usually available at a limited number of locations and usually for short time periods. Therefore simulation models have to be used. In this paper a Monte Carlo Marcov Chain (MCMC) model is presented. Precipitation series are obtained using an iterative approch starting from an arbitrary time series. The series are altered until the series have the prescribed statistical properties. Due to ist structure the model can reproduce autocorrelations and moments of observed series at different aggregation scales. In order to use the model at sites without measurements the above statistics have to be regionalized. The regionalization is based on geostatistics using external information. Topography and long term climatological variables are used to improve the interpolation. A cross validation methodology is used to validate the model. Examples from South-West Germany illustrate the methodology.

SIMULATION OF RAINFALL EVENTS FOR DESIGN PURPOSES WITH INADEQUATE DATA

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Recently the new concept of using continuous simulation in hydraulic design attracts interest. However, the absence of long rainfall records with appropriate temporal resolution, coupled with the requirement of simulating a vast number of synthetic events to calculate the flood peak for a given exceedance probability have become a barrier to the use of such approaches. Therefore, the use of design storms based on local intensity-duration-frequency (IDF) curves remains at present the most popular method not only for its simplicity but mainly because most frequently the IDF curves represent the only available information on local rainfall. Also, IDF based approaches assure the reproduction of rainfall extremes whereas continuous simulation models may fail to do so. An intermediate method lying in between the traditional design storm approach and the continuous simulation approach is presented. The method is based on, and uses as the only input, the IDF curves of a particular catchment. The main concept is to keep the design storm approach for the determination of the total characteristics of the design storm event, extracted from the IDF curves, and use a disaggregation technique to generate an ensemble of alternative hyetographs. The stochastically generated hyetographs are then entered into a rainfall - runoff model and then routed through the hydrosystem in order to simulate its hydraulic performance. The proposed method is demonstrated via examples involving sewer systems and dam spillways.

SCALING IN STOCHASTICALLY GENERATED CONTINUOUS RAINFALL TIME SERIES

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The presence of scaling statistical properties in temporal rainfall has been well established in many empirical investigations during the latest decade. These properties have more and more been regarded as a fundamental feature of the rainfall process. However, very few attempts to develop scaling-based models can be found, particularly in the case of continuous rainfall time series. One is therefore forced to use conventional time series modeling, e.g., based on point process theory, that does not explicitly take scaling into account. In this light, there is a need to investigate to which degree point process models are able to "unintentionally" reproduce the empirical scaling properties. In the present study, a 25-year series of 20-min rainfall intensities observed in Florence, Italy, was investigated. A Neyman-Scott Rectangular Pulses (NSRP) model was fitted to this series, so enabling to generate a synthetic time series suitable for investigation. A multifractal scaling behavior was found to characterise the raw data within a range of time scales between 20 min and 2 weeks. The main features of this behavior were surprisingly well reproduced in the generated data, although some differences were observed particularly at small scales below the typical duration of a raincell. This suggests the possibility of a combined use of the NSRP model and a scaling approach, in order to extend the NSRP range of suitability for simulation purposes. This possibility is presently being investigated.

SPATIAL-TEMPORAL MODELLING FOR CONTINUOUS SIMULATION

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The notion of design storm has its limitations because of its inability to take into account antecedent conditions which leads to different return periods for rainfall and flow. We present a spatial-temporal stochastic model to simulate the evolution of spatial rainfall fields over a catchment. It is based upon a Poisson-cluster process for the arrival of rain cells in storms. The model is fitted to single rainfall events from a set of UK radar data using the method of moments. Seasonal parameter sets are estimated to reproduce the diversity of rainfall types. A process of rainfall event arrivals is constructed and fitted to allow for continuous simulation.
An alternative approach using Generalized Linear Modelling of daily raingauge totals has the capability of incorporating spatial heterogeneity and assessing climate change scenarios. A hybrid method, combining the merits of both models is outlined.