Recent advances in modelling of extreme hydrologic events

Henrik Madsen and Dan Rosbjerg

Department of Hydrodynamics and Water Resources, Technical University of Denmark

EXTENDED ABSTRACT

Analysis of extreme hydrologic events is an important element in the design and operation of hydraulic structures. The first stage in the design of reservoir and flood protection structures, such as dams, spillways and dikes, is selection of the design discharge which is determined on the basis of an analysis of extreme runoff data. Estimation of extreme rainfalls forms the basis for design of urban drainage systems, and low flow characteristics are important in the design and operation of reservoirs.

At present, two different methods for extreme value analysis in hydrology are prevalent; the annual maximum series (AMS) method and the partial duration series (PDS) method, also referred to as the peak over threshold (POT) method. A fundamental difference between the two methods is the definition of the extreme value region. While the PDS method includes all exceedances above a certain threshold level, the AMS method considers only the annual maximum.

For estimation of extreme events, both sampling and model uncertainty are affected by the amount of data available at the site of interest. To obtain more efficient estimates, additional information should be included. One approach is the use of regional information, combining data from different sites in a region that can be assumed to have similar extreme hydrologic behaviour, i.e. space substitutes time to compensate for a short record at a specific site. The use of regional information reduces the sampling uncertainty by introducing more data, and, in addition, it facilitates the choice of an appropriate statistical distribution. Moreover, regionalisation forms the basis for making inferences at ungauged sites which is extremely important for a general assessment of extreme events. While much research in recent years has been directed to regional modelling based on the AMS approach, little has been done to include the PDS model in regional applications, and this is perhaps the main reason that the PDS method is much less applied in practice than the AMS method.

In this paper recent advances in modelling of extreme hydrologic events based on the PDS method are presented. Specifically, a newly developed regional estimation scheme for the PDS model is described. The procedure includes the index-flood concept of scaling and the method of *L*-moments for estimation of regional parameters, delineation of homogeneous regions and determination of regional distributions. For a more general assessment of regional homogeneity and description of regional parameters a method based on generalized least squares (GLS) regression is introduced.

As compared to the traditional approach based on AMS, the PDS method provides a more appropriate definition of the extreme value region that is seen to better capture the underlying structure and physical processes of extreme events. Moreover, simulation studies reveal that estimation based on the PDS model is generally more efficient for

both at-site and regional quantile estimation than the corresponding AMS method. Application of the PDS and AMS regional estimation schemes to New Zealand flood data indicates that the PDS method is superior with respect to both determination of homogenous regions and identification of regional distributions.

The GLS regression model is shown to provide a more efficient estimate of regional parameters for the index-flood model as compared to the usually applied record-length-weighted average approach. Moreover, the GLS model provides a general framework for a reliable assessment of parameter uncertainty and regional homogeneity. For parameters that vary significantly in the region the GLS regression model can subsequently be applied for evaluating the potential of describing the variability from physical characteristics.

Finally, to illustrate the various methodologies, an application example is presented, summarizing the results of application of the PDS model in a regional study of extreme rainfalls in Denmark.

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