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Flood frequency estimation using a joint probability method

Cecilia Svensson, Thomas R. Kjeldsen, and David A. Jones
CEH Wallingford, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, OX10 8BB, United Kingdom (csve@ceh.ac.uk)

A joint probability approach to fluvial flood estimation has been developed, that makes use of an event based rainfall-runoff model within a Monte Carlo simulation framework. In the UK, current flood estimation techniques using event based rainfall-runoff models (Kjeldsen et al., 2006) assign pre-defined design values to many of the input variables which control the size of a single flow event (design rainfall, antecedent soil moisture and initial baseflow). The exception is the rainfall magnitude, which is treated as a random variable. The model assumes a ono-to-one relationship between the return period of the design rainfall and the ensuing design flood event. Justification for the values chosen for model inputs relies to some extent on intuition and on comparing the estimated flows with estimates from other sources, in cases where these are available. In contrast, the joint probability approach presented here allows the input variables to be described by their full probability distribution, thus reducing biases in the output flood magnitudes. It has the potential to allow the eventual creation of a methodology notionally similar to the current design-event method but it would be placed within a firmer theoretical framework. The present study simulates a large number of flow events using sets of input variables from distributions fitted to observed event data, taking into account seasonality. These simulated datasets are used for driving a rainfall-runoff model, from which relevant output quantities, such as flood peak magnitudes or flow volumes, can be retrieved. A frequency analysis can then be applied to the series of, say, output flow peaks to derive a flood frequency curve. The simulated inputs are: the time between events, the intensity and duration of the rainfall event, and the soil moisture deficit (SMD) and initial river flow at the beginning of the rainfall event. There is dependence between some of the variables which needs to be considered. For example, dependence between the originally derived variables total event rainfall and duration is removed by conversion of these variables into a transformed intensity and a shifted duration. Seasonality in the variables, and temporal dependence between events, are taken into account by simulating an inter-event arrival time, so that a series of events is obtained. The initial conditions of SMD and river flow of each event are made dependent on the (simulated) time elapsed since the previous event, and on the SMD at the end of the previous event.

Reference

Kjeldsen, T. R., Stewart, E. J., Packman, J. C., Folwell, S. and Bayliss, A. 2006 Revitalisation of the FSR/FEH Rainfall-Runoff Method. R&D Technical Report FD1913/TR, Department of Environment Food and Rural Affairs, CEH Wallingford, 133pp.