Generation of daily precipitation in the Rhine basin as part of a new methodology to estimate extreme river discharges

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The Rhine is the most important river in the Netherlands. Protection against flooding of this river is a point of continuous concern. Safety standards are laid down in the Flood Protection Act. Measures against flooding in the non-tidal part of the Rhine in the Netherlands have to withstand a discharge that is exceeded on average once in 1250 years. Traditionally this design discharge has been obtained from a statistical analysis of high river discharges (data from 1901) at Lobith, the place where the river enters the country.

The last official re-evaluation of the design discharge took place in 1992 (Delft Hydraulics and EAC-RAND, 1993). Three distributions (censored Gumbel, 3-parameter lognormal and Pearson Type 3) were fitted to the annual maximum discharges at Lobith and then extrapolated to an exceedance frequency of 1/1250. The average extrapolation of the three distributions yielded a value of 14 500 m^3/s, which was corrected to 15 000 m^3/s in order to account for systematic changes in the catchment. However, it was also felt at that re-evaluation that the method of extrapolation should need a sound physical basis. Therefore, it was suggested to develop a hydrologic/hydraulical model for the entire Rhine basin to study the river discharge under extreme conditions. With such a model it would also be possible to quantify the effects of changes in the catchment on the design discharge and to predict the potential impacts of climate change.

The use of a hydrologic/hydrological model to get a better insight into the occurrence of high river discharges requires unprecedented meteorological situations as input. Therefore, a stochastic multivariate weather generator is being developed at KNMI. The emphasis is on the generation of simultaneous records of daily rainfall over the basin, but daily temperature is also considered to account for the effect of snow and frozen soils on extreme river discharges. The work is done in co-operation with the Institute for Inland Water Management and Waste Water (RIZA).

The stochastic weather generator uses a nonparametric nearest-neighbour resampling technique due to Lall and Sharma (1996). In that method daily precipitation and temperature are sampled with replacement from the most similar days in the historic record (the nearest neighbours or analogues). Apart from the hydrological literature on nearest-neighbour resampling, there is an independent development of the use of analogues for generating synthetic rainfall sequences in climate change studies (Zorita *et al*, 1995). The main advantage of a nonparametric resampling technique is that it preserves the spatial association of 1-day rainfall. It is, however, not sure how far the autocorrelation structure of the daily data can be reproduced. This strongly depends on the variables used to select the analogues of the new day in the generated record. Good results have been obtained by considering the generated precipitation and temperature for the previous day and atmospheric circulation variables.

A comparison between the extreme-value distributions of observed rainfall and those derived from the generated sequences is an important test of the performance of the chosen simulation technique. With regard to the extreme river discharges at Lobith, large rainfall over periods of 4 to 20 days during the winter half-year (October - March) is of interest. Extreme-value distributions for these multi-day periods are examined both for single-site rainfall and area-average rainfall over parts of the Rhine basin. In addition, the reproduction of the spatial association of extreme multi-day rainfall amounts is discussed.

References

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