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Estimating extreme floods of low probabilities by a physically-based model of snowmelt runoff formation combined with a stochastic weather generator

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Application of a dynamic-stochastic model, which combines a physically based model of runoff formation and a stochastic weather generator, has been proposed as an alternative to the standard flood frequency analysis in the cases of short series of recorded flood events or non-stationarity of these series caused by the man-induced changes of river basins. The case studies have been carried out for the Vyatka River basin (the catchment area is 120000 sq.km) and the Seim River basin (the catchment area is 7460 sq.km) in European Russia. The physically based model of runoff generation is based on the finite-element schematization of river basin and describes the main runoff generation processes (snow cover formation and snowmelt, freezing and thawing of soil, vertical soil moisture transfer and infiltration, overland, subsurface and channel flow). The stochastic weather generator is constructed on the basis of the available meteorological records and includes stochastic models that allow one to simulate time series of daily precipitation, air temperature, and air humidity. The long meteorological time series simulated by the Monte Carlo procedure are used as the inputs into the physically based model to calculate the flood hydrographs and to estimate the exceedance probabilities of the flood peak discharges. To reduce uncertainty of the estimations caused by the errors of the model inadequacy and insufficient lengths of the hydrometeorological observation series, the estimated exceedance probabilities have been fitted by the SB Johnson distribution in which one from the parameters is assigned as the probable maximum flood (PMF) peak discharge. This value has been determined from the physically based model where the input is the probable maximum snowmelt rate during the basin concentration time. To calculate the probable maximum snowmelt rate,

the snowmelt heat balance components have been maximized. Sensitivity of the estimated quantiles to the errors of the PMF calculations has been studied and it has been shown that the flood peak discharges of low exceedance probabilities (0.001-0.0001) are not strongly sensitive to the errors of the PMF calculations.