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On the thresholds in modeling of high flows via artificial neural networks - A bootstrapping analysis

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Considering the growing interest in simulating hydrological phenomena with artificial neural networks (ANNs), it is useful to figure out the potential and limits of these models. In this study, the main objective is to examine how to improve the ability of an ANN model to simulate extreme values of flow utilizing a priori knowledge of threshold values. A three-layer feedforward ANN was trained by using the back propagation algorithm and the logistic function as activation function. By using the thresholds, the flow was partitioned in low ($x < \mu$), medium ($\mu \leq x \leq \mu + 2\sigma$) and high ($x > \mu + 2\sigma$) values. The employed ANN model was trained for high flow partition and all flow data too. The developed methodology was implemented over a mountainous river catchment (the Mesochora catchment in northwestern Greece). The ANN model received as inputs pseudo-precipitation (rain plus melt) and previous observed flow data. After the training was completed the bootstrapping methodology was applied to calculate the ANN confidence intervals (CIs) for a 95% nominal coverage. The calculated CIs included only the uncertainty, which comes from the calibration procedure. The results showed that an ANN model trained specifically for high flows, with a priori knowledge of the thresholds, can simulate these extreme values much better (RMSE is 31.4% less) than an ANN model trained with all data of the available time series and using a posteriori threshold values. On the other hand the width of CIs increases by 54.9% with a simultaneous increase by 64.4% of the actual coverage for the high flows (a priori partition). The narrower CIs of the high flows trained with all data may be attributed to the smoothing effect produced from the use of the full data sets. Overall, the results suggest that an ANN model trained with a priori knowledge of the threshold values has an increased ability in simulating extreme values compared with an ANN model trained with all the data and a posteriori knowledge of the thresholds.