Geophysical Research Abstracts
Vol. 12, EGU2010-9708, 2010
EGU General Assembly 2010

Tests of Climate Change Effects on the Applicability of Flood Frequency Analysis in the Fulda Catchment Area, Germany

Gabriel Stefan Maria Fink and Manfred Koch
Department of Geohydraulics and Engineering Hydrology, University of Kassel, Germany

An important aspect in hydrological engineering is the assessment of flood risk as a basis for the dimensioning of various hydraulic structures. The central element of such a risk assessment is flood frequency analysis (FFA) which itself is based on extreme value statistics theory. Despite the progress of methods in this scientific branch, the development, decision, and fitting of an appropriate distribution function still remains a challenge, particularly, when certain underlying assumptions of the theory are not met in real applications. This is, for example, the case when the stationarity-condition for a random flood time series is not satisfied anymore as could be the situation when long-term hydrological impacts of future climate change are to be considered.

The objective of this study is to verify the applicability of FFA's to simulated flood time series in the 21st century. The main interest is to see whether the underlying conditions for the application of extreme value statistic are still valid under the impact of long-term climate change on global and regional flood regimes resp. hydrological systems.

The object of the investigation is the Fulda catchment with a size of 6930 km^2 in central Germany. This hydrological system is simulated with the distributed hydrological model SWAT (Soil and Water Assessment Tool). Calibration and validation of the model with measured daily flow data has been carried out for the (C20) periods 1960-76 and 1977-2004, respectively, and result in a good fit (as quantified by the RN^2) of the simulated to the modeled daily mean runoff. The climate data used for the hydrological predictions for the 2001-2100 time period are the results of dynamically downscaled calculations with the regional model REMO, the latter using the output of the global circulation model ECHAM5 MPI-OM. The three IPCC-scenarios A1B, A2, and B1 are tested in the subsequent SWAT hydrological simulations, using the predicted climate variables precipitation, maximum and minimum daily temperature, and relative humidity. The calibration-validation period 1960-2000 serves as a reference period for the 21st century predictions.

To test the FFA conditions for the simulated flood time series of the 21st century, the whole investigation period 1960-2100 has been split into the parts C20 (1960-2000), T1 (2001-2050), and T2 (2051-2100), each of which is then subjected to various statistical time-series tests. For example, a simple test of the stationarity of the mean cannot indicate significant changes in the mean behavior between these periods. Additionally, the 2-test leads to the adaption of the hypothesis that there is no change in the distribution function for all three climate scenarios. The application of the Mann-Whitney trend test and the Mann-Kendall trend test prove the stationarity (=0.05) of the flow time series. Wald-Wolfowitz tests and the analyses of auto-covariance and auto-correlation function show that the flood's independence and randomness cannot be dismissed. Only for scenario B1 a significant dependence between the yearly flood maxima can be detected. The calculation of the Hurst coefficient H with 7 different methods shows that despite the present problem of a too short time series (n=100), there is a tendency to long-term persistence, as H lies between 0.5 and 0.7. Although there are graphically recognizable changes in the flood probabilities, these prove to be not statistically significant. Therefore, in conclusion, there is no evidence for an effect of 21st century climate change impact on the flood regime in the Fulda watershed area. This means that there should be no conflict when FFA is applied to 21st century flood extremes in this catchment. Of course, the results obtained in this study cannot be transferred to other hydrological systems.