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Flood Frequency Analysis for Nonstationary Annual Peak Records in an Urban Drainage Basin

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Flood frequency analysis in urban watersheds is complicated by nonstationarities of annual peak records associated with land use change and evolving urban stormwater infrastructure. In this study, a framework for flood frequency analysis is developed based on the Generalized Additive Models for Location, Scale and Shape parameters (GAMLSS), a tool for modeling time series under nonstationary conditions. GAMLSS is applied to annual maximum peak discharge records for Little Sugar Creek, a highly urbanized watershed which drains the urban core of Charlotte, North Carolina. It is shown that GAMLSS is able to describe the variability in the mean and variance of the annual maximum peak discharge by modeling the parameters of the selected parametric distribution as a smooth function of time via cubic splines. Flood frequency analyses for Little Sugar Creek (at a drainage area of 110 km^2) show that the 100-year flood peak over the 83-year record has ranged from a minimum unit discharge of 2.1 $m^3 s^{-1} km^{-2}$ to a maximum of 5.1 $m^3 s^{-1} km^{-2}$. An alternative characterization can be made by examining the return interval of the peak discharge that has a return interval of 100 years (3.2 $m^3 s^{-1} km^{-2}$), based on the assumption that the 83-year record is stationary. Under the GAMLSS model, the return interval of an annual peak discharge of 3.2 $m^3 s^{-1} km^{-2}$ ranges from a maximum value of more than 5000 years in 1957 to a minimum value of almost 8 years for the present time (2007). The GAMLSS framework is also used to directly examine the links between population trends and flood frequency, as well as trends in annual maximum rainfall. These analyses are used to examine evolving flood frequency over future decades.