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Is the Gumbel distribution sufficiently flexible to model annual maxima series of Irish Rivers?

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Introduction: Generalised extreme value (GEV) type I (Gumbel) distributions are recommended for estimating the flood quantiles from single site flood frequency analysis in Irish river catchments (NERC, 1975). Applying type I distributions is relatively simple and is associated with lower standard errors of both scale and location parameters. Corresponding estimates of flood quantiles for shorter period flow records are also more accurate. However, it remains unclear whether the two parameter type I distribution of constant skewness is sufficiently flexible to account for variations in the shape of the flood frequency distribution that can result from floodplain influences in Irish river catchments. Floodplains provide extra storage to flood water and increase the hydraulic resistance on the overbank zone, delaying and attenuating the flood wave as it passes down to the river network. This results in mildly graded flood frequency curves at gauging stations downstream of floodplains and consequently, the assumption of type I distribution at these locations may produce errors in estimated flood quantiles.
Objective: This paper identifies the influences of floodplain attenuation effects on flood wave propagation and the significance this may have when undertaking a flood frequency analysis at a particular site. Seven floodplain affected Irish rivers (the Rivers Clare, Dee, Glyde, Maigue, Nore, Suck and Suir) where multiple gauging stations with long flow records are currently active in the main river stems are considered.
Methods: The study was undertaken in a number of stages. Annual maxima (AM) and 15 minutes time series flow data from 17 Irish gauging stations of the 7 rivers with record length varying from 29 to 58 years were obtained. Flood attenuation polygons which represent the lateral extent of floodplain inundation for different return period floods were obtained from the Irish Office of Public Works (OPW) for use with a GIS platform. Initial analysis involved an application of the Hosking et al. (1985) goodness of fit test that is based on L-moment parameter estimation to identify the GEV family distribution that best fits the AM data at each of the 17 gauging stations. Results were confirmed by the application of a modified Anderson Darling (Laio, 2004) goodness of fit test based on maximum likelihood parameter estimation. Following this, the downstream transformation of the flood frequency distribution in each river was identified by including the identified GEV distributions in an ArcGIS platform with the flood attenuation polygons. The final stage of the analysis involved a peaks over threshold (POT) analysis in which independent flood peaks were extracted from 15-minute time series flow

data at each gauging station. Specified thresholds were set using a rule of independence as outlined in the Flood Studies Report (NERC, 1975). The extracted POT series facilitated an estimate of the flood peak travel time from upstream to downstream stations for a range of flow conditions and from these travel times, relationships between wave speed and discharge for inbank and overbank flows were established. These relationships indicated that travel times were lower for floodplain affected flows and provided additional support to hypothesis that floodplain influences can produce shifts in flood frequency distributions.
Results: The Hosking goodness of fit statistical test results and potential percentage errors in 100 years flood quantile estimation for the seven rivers investigated that could result from assuming a Gumbel distribution where another GEV distribution is more

appropriate from upstream to downstream gauging stations are shown below:
Clare 30004 (GEV type II) error (-18.18) - 30007 (GEV type III) error (15.57)
Dee 06013 (GEV type I) error (10.87) - 06025 (GEV type III) error (13.14)
Glyde 06014 (GEV type II) error (-7.42) - 06021 (GEV type I) error (7.27)
Maigue 24004 (GEV type I) error (-1.27) - 24008 (GEV type I) error (9.39) - 24082 (GEV type III) error (16.78)
Nore 15002 (GEV type I) error (4.95) - 15004 (GEV type I) error (5.46) - 15006 (GEV type III) error (14.91)
Suck 26006 (GEV type II) error (-18.15) - 26007 (GEV type I) error (-7.35)
Suir 16002 (GEV type I) error (2.53) - 16004 (GEV type I) error (-10.72) - 16008 (GEV type III) error (11.74)

Conclusions: The presence of a GEV type III station in areas where floodplain activity is likely suggests that when gauging stations are separated by wide shallow floodplains without significant intervening tributary inflows, there is an increased tendency for flatter GEV type III flood frequency distributions at downstream gauging stations. Results also indicate that in some instances, assuming the GEV type I (as recommended for analysing Irish river catchments) distribution is incorrect and may result in erroneous estimates of flood quantile at these stations. Where actual data follows a type II distribution, flood quantiles may be underestimated by in excess of 18

References

Hosking, J.R.M., Wallis J. R. and Wood E.F.: Estimation of the generalized extreme value distribution by the method of Probability-Weighted Moments, Technometrics, 27(3): 251-260, 1985.
Laio, F.: Cramer-von Mises and Anderson-Darling goodness of fit tests for extreme value distributions with unknown parameters, Water Resour. Res., 40, 1-10, 2004.
NERC (Natural Environment Research Council): Flood Studies Report. Vol. I, Hydrological Studies, London, 1975.