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Hydrology and Earth System Sciences Discussions

Interactive comment on "Influences on flood frequency distributions in Irish river catchments" *by* S. Ahilan et al.

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Dear Reviewer,

The authors would like to thank you for your detailed comments regarding manuscript HESS-2011-71 entitled "Influences on flood frequency distributions in Irish river catchments" for publication in the HESS Journal.

All comments, both general and have been considered and addressed as follows:

Reviewer Comments - General Comments:

An implicit assumption of this study is that the time series are stationary. However,

some of the catchments are urbanized (Figure 8 and text at the beginning of pg. 3330), and there may be indication of a climate change signal (top of pg. 3331). Moreover, I find it a bit hard to believe that all these catchments are pristine or free from anthropogenic effects. I think that the Authors should examine whether stationarity is a reasonable assumption.

The authors accept that this is a reasonable comment. The inherent assumptions behind traditional flood frequency analysis of AM flow series are that they are independent and identically distributed. Should these assumptions be invalid, traditional flood frequency methods become unreliable. Reviewer 2 has questioned the validity of these assumptions in the context of the work undertaken with particular regard to the influences of urbanisation and climate change on Irish catchments.

The introduction of "impervious" surfaces inhibits infiltration and reduces surface retention. The magnitude of these effects however, is not constant for a particular catchment and depends not only on the degree of urbanization, but also the storm characteristics. In this study, the urbanized fraction of almost all of the catchments investigated was less than 5%. Hollis (1975) showed that floods with a return period of 1 yr or more are not considerably affected by 5% paving of their catchment and on this basis, the authors believe that stationarity with regard to urbanization is a reasonable assumption. Furthermore, results of the study show that the GEV shape parameters are not particularly sensitive to urbanisation levels for the catchments investigated.

Reviewer 2 also suggests that climate change may have an impact on the stationarity assumption. Current climate change studies are associated with many uncertainties and there are still no fully definitive conclusions on the influence of climate change on Irish flow data. Recent research undertaken as part of the Irish Flood Studies Update Programme investigated the assumption of stationarity in Irish AM data series using the parametric t-test and non-parametric Mann-Whitney U test (MW-t test). The Irish AM data for Irish gauges were discretised into distinct time periods to detect any step change in the data series. This study failed to identify any clear climate change trends

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and on this basis assumption of stationarity for climate change influences is considered reasonable for the majority of the Irish gauging stations.

RC1 Figure 1: instead of a pie chart, please show a histogram with the record length. The Authors should also show the time period covered by these stations.

AC1 The authors agree that the data for Figure 1 may be better represented in a histogram rather than a pie chart. However, after careful consideration, the authors feel that any diagram will not significantly add to the paper and are in agreement with Reviewer 1 that this data could be provided easily within the text. This figure has therefore been removed from the revised manuscript and the text has been amended accordingly.

RC2 I am a bit confused: do the Authors model 172 stations or only the 143 stations with a record exceeding 25 years?

AC2 Annual Maxima data from 172 Irish gauging stations was used for this study. However to have a sufficient discriminating power, the Hosking et al. (1985) goodness of fit test requires test sample sizes (n) should be greater than 25. The record lengths of only 143 of the 172 stations analysed met this requirement and this data was used on the Hosking et al test. However, data for the full 172 stations was used in the preparation of Moment and L-moment diagrams and also in the descriptive statistics of the various catchments presented in the revised manuscript.

RC3 I don't necessarily agree with the interpretation of the results. The fact that we cannot reject the null hypothesis that the data were generated from a GEV distribution does not mean that the data were generated from a GEV distribution. In general, we won't be able to know what the parent distribution is, but we can say whether there is enough evidence to reject the null hypothesis that the data were generated from a particular distribution. As indicated by Reviewer 1, it is likely that other distributions would have led to the same conclusion.

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AC3 Previous studies undertaken as part of both the Flood Studies Report and Irish Flood Studies Update support strongly the assumption that a GEV distribution (as opposed to another distribution) provide the most suitable 'fit' for Irish AM data. While it is possible that other distributions may also be valid, this was not explored in this study.

RC4 In a study of this kind, I think that the Authors should explain why they did not include maximum likelihood estimators.

AC4 Hosking (1990) and Hosking and Wallis (1997) noted that L-moment ratios are more robust in the presence of extreme values and do not have sample size related bounds. In general, the bias of small sample estimates of higher-order L-moments is small. These represent considerable benefits over product moment ratios. Moreover, Van Gelder (1999) illustrated that the required computation L-moment technique is quite limited and it yields better results with non homogeneous data compared with other traditional techniques, such as maximum likelihood and least-squares estimators. The text of the revised manuscript has been amended to include reasons why L-moment ratios are suitable in these analyses.

RC5 I would have personally used other formal goodness-of-fit tests (e.g., Kolmogorov-Smirnov, Cramer-von Mises, Anderson-Darling, probability plot correlation coefficient). The critical value of the test statistic could be computed using a Monte Carlo approach.

AC5 Different goodness-of-tests can be employed to address the same statistical problem. In this study, probability plots, Moment and L-moment diagrams and the Hosking goodness of test were used to identify the suitable GEV distribution. The theory and application of L-moments introduced by Hosking (1990) is now a widely accepted approach for evaluating the goodness of fit of alternative distributions to observations (Hosking and Wallis, 1997 and Stedinger et al., 1993) and is particularly useful for small sample sizes. For this reason, and not withstanding that other statistical tests would also have been appropriate, this approach was used in this study. Furthermore Monte Carlo tests were undertaken to investigate the uncertainties arising from limited

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samples and sample sizes in the study.

RC6 Is it really meaningful to compute the 100-year flood peak from 25 years of data?

AC6 It is not meaningful to compute the 100-yr flood peak from 25 yr of data and the Flood Study Report FSR (NERC, 1975) recommended that the return period of the estimated flow in a single site analysis should not exceed the length in years of the available flow record by more than a factor of two (at least 50 yr of data should be used to estimate the 100-yr flood). We therefore have now only included 100-yr flood peak at sites where a minimum 50 yr flow record is available. This change is reflected in in the revised manuscript.

RC7 Pg. 3320: please include a reference for equation 9.

AC7 Equation 9 was developed for the Irish National Flood Studies Update FSU programme which represents a similar body of work to the Flood Estimation Handbook currently used in the UK. A reference from Reed and Martin (2005) has been included as suggested.

RC8 Figure 3: are the relationships in panels a, c, and e really useful? The plots are in the log-log scale and there are differences of almost two orders of magnitude.

AC8 The authors feel that a, c and e in Figure 3 are useful. While the authors agree that there is data scatter in panels a, c and e, it would be unlikely to get perfect relationships for plots of this kind from 'real' data. Plots of this type are useful for developing simple regression relationships for mean and median discharges in terms of catchment descriptors and have been produced in the Flood Studies Report (NERC, 1975) for these purposes. The level of scatter that is observed highlights that there is no substitute for site specific data and relationships of this type can produce estimates with significant errors.

RC9 Figure 4: I think that the Authors should include confidence intervals to show that the GEV fits significantly better than the Gumbel.

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AC9 95% confidence intervals have been included in Figure 4 (revised manuscript) as suggested and these show that GEV distributions are a better fit to the presented data than Gumbel distributions.

RC10 Figure 6: Once confidence intervals are included, I don't think that the results from the three distributions are statistically different.

AC10 Figure 6 (in original manuscript) shows that results from the three GEV family distributions are within the 95% confidence interval of the GEV type I quantile estimate. However when we assume GEV type I distributions where GEV type II or type III are more appropriate, considerable differences are observed between quantile estimates for these distributions. An objective of the study is to question, from the perspective of those engaged in flood estimation in Irish catchments, the assumption that GEV type I distributions are suitable for Irish AM data and to identify the errors when this assumption is incorrect (the case in karst and floodplain affected catchments).

RC11 Figure 7: please remove the blue background to improve readability. Also, I think that the clusters are rather subjective and I don't really see them.

AC11 The readability of the diagrams in Figure 7 has been improved by the removal of the blue background as suggested. The issue of the subjectivity of the clustering of the various distributions was also raised by Reviewer1 and has been addressed in our Reviewer 1 comments.

RC12 - Pg. 3306, line 7: "Analysis of these data"

AC12 As suggested, "Analysis of this data" is changed to "Analysis of these data" in the revised manuscript.

RC13 - Pg. 3307, line 13: what does "confidence level" mean in this case?

AC13 The authors agree that the term "confidence level" in this context is not accurate. The text has been revised to discuss the data in terms of a "quality level".

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Interactive Comment

RC14 - Pg. 3322, line 7: “short tail”

AC14 “short tale” has been changed to “short tail”.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 3305, 2011.