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Simulating Confidence Intervals for T-Year Floods

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0.1 Assumptions:

The operating assumption, as given in Bulleting 17B (Guidelines for Determining Flood-Flow Frequency, Water Resources Council Hydrology Committee, Bulletin 117B, Washington, D.C., 1981), is that the logarithms of the yearly peak discharges at a site have a Pearson III Probability distribution. The probability density function for a Pearson III distribution has the form

$$f(x) = \frac{1}{|a|}\frac{1}{\Gamma(b)}\left[\frac{x-c}{a}\right]^{b-1} e^{-\frac{x-c}{a}},$$

For $\frac{x-c}{a} > 0$ and zero for $\frac{x-c}{a} < 0$. In terms of the skew γ for the site, $\gamma^2 = \frac{4}{b}$ with γ having the same sign as the parameter a. The case of zero skew is the limiting case as b tends to infinity and can be shown to give a normal distribution.

0.2 Skew:

The skew can be estimated from data at the site or by an estimate combin-ing data from several surrounding sites or from a skew map which represents combined estimates. We will take the skew as being given and compute confi-dence limits for the T-year flood using this given (and therefore assumed exactly correct) skew.

0.3 Confidence Limits

A one-sided 100q percent confidence interval, also known as a confidence level, *Lq* for the T-year flood value *tp*, $p = 1 - 1/T$, is computed from the data for the site being studied so as to have the following property: If there were an indefinitely large number of sites like the one being studied, each with a log Pearson III distribution for the yearly maximal discharges, each with the same number of site values, and each site with the same skew, then upon repeated sampling from these sites, the procedure for calculating *Lq* will give values with the property that the true T-year value *tp* in the long run will lOOq percent of the time be less than the calculated values *Lq*. Note that *Lq* is not a single number, but a method for calculating a number and this method gives a correct upper limit for the true T-year flood value 100q percent of the time.

Think of it as a safety measure. Any estimate of the true T-year flood value will just be an estimate, but it can be adjusted upwards in a way which provides some predetermined safety level, i.e. which will assure the user that the T-year flood value will be less than or equal to *Lq* with as high a long run frequency q as the user chooses.

0.4 Bulletin 17B Confidence Limits Not Accurate:

It has been known for a long time that the methodology suggested in Bulletin 17B for computing confidence intervals is not accurate. One reference is the important paper of J. Stedinger (Confidence Intervals for Design Events, J. of Hydraulic Engineering 109(1983) 13-27) in which he gives an approximate formula for confidence limits that is, for small skew, a good approximation.

0.5 Simulating Confidence Limits

A simulation approach to computing confidence intervals was given in Robert Whitley and T. V. Hromadka II, Computing Confidence Intervals for Floods I, Microsoftware for Engineers 3(1986)138-150. It is now possible to compute confidence levels with high accuracy using this approach because of the remarkable increase in computing power. As an example, based on the program run times given in the paper cited above, a program which in 1986 would have taken 40 hours to run now takes 10 seconds! This increase in speed is due to better compliers and available scientific libraries of fine-tuned subroutines, as well as faster computers.

The computed 100q percent one-sided confidence intervals have the form

$$Lq = \hat{\mu} + Cq\,\hat{\sigma} \qquad (1)$$

where the constant *Cq* depends upon the value T for the T-year flood and the number of years of maximal discharge data available at the site as well as on q, $\hat{\mu}$ is the estimated mean of the log discharge data and $\hat{\sigma}$ is the estimated standard deviation. Since this limit is for the log of the discharge, say $\log_{10}(Q)$, the confidence level for the flood Q is 10^{Lq}.

0.6 Computational Accuracy:

In the program we use, the *Cq*, are computed with eight distinct samples of 100,000 sites each, and are averaged to get the final *Cq* values. These values are tested for the 101 q values of q = 0.005, 0.01, 0.02, ... ,0.98, 0.99, 0.995 by means of four 1,000,000 sites tests which are based on a random number generator (with long period 2^{31} - 1) which is not the same as the random number generator used in computing the *Cq*. The way the *Cq* are tested is that in each of the four tests, for 1,000,000 sites values of $\hat{\mu}$ and $\hat{\sigma}$ are computed and a count is kept of the fraction of the time the number in equation (1) is greater than or equal to the actual T-year flood value: This fraction, testq, should be q. The error is reported as 100*(q-testq) in the graphs of the two examples given.

The two examples of these computation are both for the T=100 year flood, 10 points at the site, and with skews of + 1.0 and -1.0. The tests graphed and given as tables are each the first of the four tests; all four tests are similar. So as a sample from skew =-1.0, the fraction for q =.1 is not .1 but is testq = .100203. As a sample from skew = +1.0, the fraction for q =.9 is testq =.899569.

26-Aug-04
Output from fixconA
T-year flood T = 100.0 number of site data point = 10 skew = -1.00
Test number 1

q	Test of Cq	100*q	100*(q-testq)
0.005	0.004882	0.5	0.0118
0.01	0.009848	1	0.0152
0.02	0.019815	2	0.0185
0.03	0.029733	3	0.0267
0.04	0.039595	4	0.0405
0.05	0.049516	5	0.0484
0.06	0.059752	6	0.0248
0.07	0.069912	7	0.0088
0.08	0.080154	8	-0.0154
0.09	0.090211	9	-0.0211
0.10	0.100203	10	-0.0203
0.11	0.110489	11	-0.0489
0.12	0.120668	12	-0.0668
0.13	0.130591	13	-0.0591
0.14	0.140543	14	-0.0543
0.15	0.150633	15	-0.0633
0.16	0.160486	16	-0.0486

q	Test of Cq	100*q	100*(q-testq)
0.17	0.170528	17	-0.0528
0.18	0.180334	18	-0.0334
0.19	0.190368	19	-0.0368
0.20	0.200314	20	-0.0314
0.21	0.210604	21	-0.0604
0.22	0.220512	22	-0.0512
0.23	0.230552	23	-0.0552
0.24	0.240658	24	-0.0658
0.25	0.250571	25	-0.0571
0.26	0.260499	26	-0.0499
0.27	0.270407	27	-0.0407
0.28	0.280524	28	-0.0524
0.29	0.290697	29	-0.0697
0.30	0.300589	30	-0.0589
0.31	0.310407	31	-0.0407
0.32	0.32028	32	-0.028
0.33	0.330293	33	-0.0293
0.34	0.340122	34	-0.0122
0.35	0.349952	35	0.0048
0.36	0.36021	36	-0.021

q	Test of Cq	100*q	100*(q-testq)
0.37	0.370058	37	-0.0058
0.38	0.38003	38	-0.003
0.39	0.390039	39	-0.0039
0.40	0.400063	40	-0.0063
0.41	0.410021	41	-0.0021
0.42	0.420127	42	-0.0127
0.43	0.429846	43	0.0154
0.44	0.439848	44	0.0152
0.45	0.449854	45	0.0146
0.46	0.459955	46	0.0045
0.47	0.470081	47	-0.0081
0.48	0.480234	48	-0.0234
0.49	0.490095	49	-0.0095
0.50	0.500142	50	-0.0142
0.51	0.510253	51	-0.0253
0.52	0.520431	52	-0.0431
0.53	0.530382	53	-0.0382
0.54	0.54017	54	-0.017
0.55	0.550093	55	-0.0093
0.56	0.560068	56	-0.0068
0.57	0.570209	57	-0.0209
0.58	0.580432	58	-0.0432

q	Test of Cq	100*q	100*(q-testq)
0.59	0.59051	59	-0.051
0.60	0.600502	60	-0.0502
0.61	0.610623	61	-0.0623
0.62	0.620645	62	-0.0645
0.63	0.630717	63	-0.0717
0.64	0.640795	64	-0.0795
0.65	0.650683	65	-0.0683
0.66	0.660746	66	-0.0746
0.67	0.670659	67	-0.0659
0.68	0.680812	68	-0.0812
0.69	0.690866	69	-0.0866
0.70	0.700779	70	-0.0779
0.71	0.710388	71	-0.0388
0.72	0.720256	72	-0.0256
0.73	0.730191	73	-0.0191
0.74	0.740081	74	-0.0081
0.75	0.750082	75	-0.0082
0.76	0.76014	76	-0.014
0.77	0.769958	77	0.0042
0.78	0.77995	78	0.005
0.79	0.790024	79	-0.0024

q	Test of Cq	100*q	100*(q-testq)
0.80	0.799957	80	0.0043
0.81	0.81008	81	-0.008
0.82	0.819907	82	0.0093
0.83	0.830382	83	-0.0382
0.84	0.840246	84	-0.0246
0.85	0.85047	85	-0.047
0.86	0.860481	86	-0.0481
0.87	0.870576	87	-0.0576
0.88	0.880508	88	-0.0508
0.89	0.8904	89	-0.04
0.90	0.900452	90	-0.0452
0.91	0.910521	91	-0.0521
0.92	0.920638	92	-0.0638
0.93	0.930293	93	-0.0293
0.94	0.940239	94	-0.0239
0.95	0.95035	95	-0.035
0.96	0.960447	96	-0.0447
0.97	0.970249	97	-0.0249
0.98	0.980069	98	-0.0069
0.99	0.990095	99	-0.0095
0.995	0.995072	99.5	-0.0072

26-Aug-04
Output from fixconA
T-year flood T = 100.0 number of site data point = 10 skew = 1.00
Test of Cq coefficient for selected q values
Test number 1

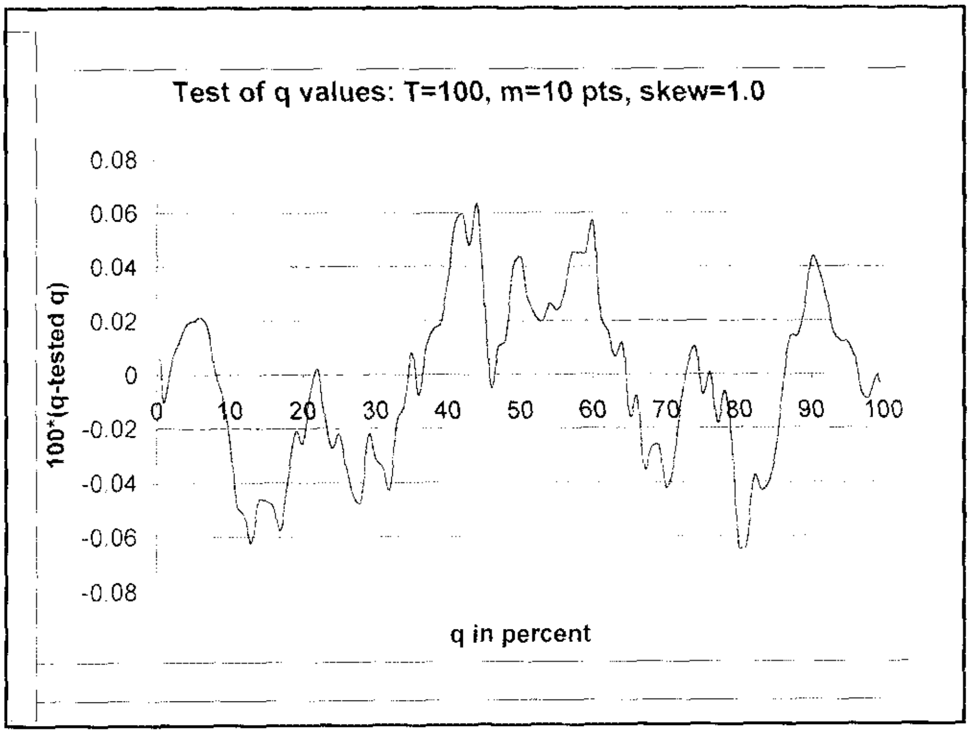
q	Test of Cq	100*q	100*(q-testq)
0.005	0.004941	0.5	0.0059
0.01	0.010105	1	-0.0105
0.02	0.019956	2	0.0044
0.03	0.029888	3	0.0112
0.04	0.039816	4	0.0184
0.05	0.049801	5	0.0199
0.06	0.059789	6	0.0211
0.07	0.06983	7	0.017
0.08	0.079992	8	0.0008
0.09	0.090077	9	-0.0077
0.10	0.100247	10	-0.0247
0.11	0.110483	11	-0.0483
0.12	0.120519	12	-0.0519
0.13	0.130623	13	-0.0623
0.14	0.140464	14	-0.0464

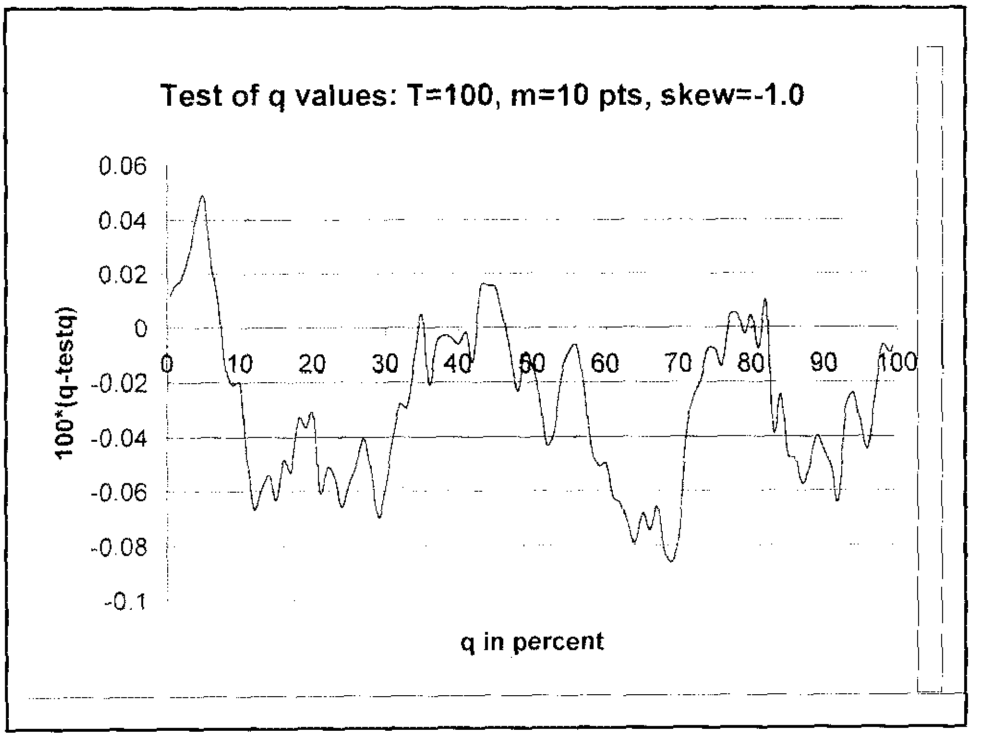
q	Test of Cq	100*q	100*(q-testq)
0.15	0.150469	15	-0.0469
0.16	0.160492	16	-0.0492
0.17	0.170575	17	-0.0575
0.18	0.180379	18	-0.0379
0.19	0.190212	19	-0.0212
0.20	0.200256	20	-0.0256
0.21	0.21007	21	-0.007
0.22	0.219981	22	0.0019
0.23	0.23016	23	-0.016
0.24	0.240274	24	-0.0274
0.25	0.250222	25	-0.0222
0.26	0.260351	26	-0.0351
0.27	0.27045	27	-0.045
0.28	0.280474	28	-0.0474
0.29	0.290225	29	-0.0225
0.30	0.300309	30	-0.0309
0.31	0.310346	31	-0.0346
0.32	0.320423	32	-0.0423
0.33	0.330167	33	-0.0167
0.34	0.340121	34	-0.0121
0.35	0.349918	35	0.0082
0.36	0.360077	36	-0.0077

q	Test of Cq	100*q	100*(q-testq)
0.37	0.369906	37	0.0094
0.38	0.379831	38	0.0169
0.39	0.389809	39	0.0191
0.40	0.399648	40	0.0352
0.41	0.409441	41	0.0559
0.42	0.419402	42	0.0598
0.43	0.429522	43	0.0478
0.44	0.439373	44	0.0627
0.45	0.449727	45	0.0273
0.46	0.46005	46	-0.005
0.47	0.469901	47	0.0099
0.48	0.479874	48	0.0126
0.49	0.489598	49	0.0402
0.50	0.499565	50	0.0435
0.51	0.509711	51	0.0289
0.52	0.519783	52	0.0217
0.53	0.529803	53	0.0197
0.54	0.539737	54	0.0263
0.55	0.549764	55	0.0236
0.56	0.559709	56	0.0291
0.57	0.569553	57	0.0447
0.58	0.579552	58	0.0448

q	Test of Cq	100*q	100*(q-testq)
0.59	0.589548	59	0.0452
0.60	0.599436	60	0.0564
0.61	0.609784	61	0.0216
0.62	0.619841	62	0.0159
0.63	0.629938	63	0.0062
0.64	0.639889	64	0.0111
0.65	0.650156	65	-0.0156
0.66	0.660086	66	-0.0086
0.67	0.670349	67	-0.0349
0.68	0.68027	68	-0.027
0.69	0.690268	69	-0.0268
0.70	0.700421	70	-0.0421
0.71	0.710332	71	-0.0332
0.72	0.720104	72	-0.0104
0.73	0.729956	73	0.0044
0.74	0.739902	74	0.0098
0.75	0.750075	75	-0.0075
0.76	0.759996	76	0.0004
0.77	0.770182	77	-0.0182
0.78	0.780063	78	-0.0063
0.79	0.790259	79	-0.0259
0.80	0.800638	80	-0.0638

q	Test of Cq	100*q	100*(q-testq)
0.81	0.81064	81	-0.064
0.82	0.82038	82	-0.038
0.83	0.830431	83	-0.0431
0.84	0.840404	84	-0.0404
0.85	0.850297	85	-0.0297
0.86	0.860056	86	-0.0056
0.87	0.86986	87	0.014
0.88	0.879861	88	0.0139
0.89	0.88976	89	0.024
0.90	0.899569	90	0.0431
0.91	0.909614	91	0.0386
0.92	0.91971	92	0.029
0.93	0.929836	93	0.0164
0.94	0.939874	94	0.0126
0.95	0.949883	95	0.0117





Test of q values: T=100, m=10 pts, skew=-1.0
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
0 10 20 30 40 50 60 70 80 90 100
100*(q-testq)
q in percent