

Robustness of estimators for flood statistics

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Table 1. Estimation of the 99 %- and the 99.9 %-quantile for independent, identically Gumbel (100, 10)-distributed random variables with sample size 30, 50, 100 and 200.

<i>n</i> = 30 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	99.9%-quantile RMSE	99.9%-quantile Bias	99.9%-quantile RMSE	99%-quantile Bias	99.9%-quantile RMSE	99.9%-quantile Bias	99.9%-quantile RMSE
ML	-1.14	7.39	-1.78	10.7	0.797	18.4	9.62	77.3
L-Moments	-0.398	8.08	-0.609	11.7	0.136	14.0	4.58	35.5
TL(1,1)-Moments	-0.114	8.27	-0.139	12.1	4.14	22.3	21.2	74.8
TL(0,1)-Moments	0.418	7.77	0.626	11.2	9.86	36.9	37.7	124
MD	-0.816	8.67	-1.28	12.7	6.47	32.7	36.4	168
<i>n</i> = 50 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	99.9%-quantile RMSE	99.9%-quantile Bias	99.9%-quantile RMSE	99%-quantile Bias	99.9%-quantile RMSE	99.9%-quantile Bias	99.9%-quantile RMSE
ML	-0.295	5.61	-0.52	8.07	-0.9	11.1	1.00	26.8
L-Moments	0.078	6.45	0.108	9.37	0.593	10.6	3.27	25.0
TL(1,1)-Moments	-0.176	6.47	0.283	9.54	3.08	16.4	13.3	48.2
TL(0,1)-Moments	0.155	5.99	0.243	8.66	3.46	21.4	13.4	57.1
MD	-0.362	6.60	-0.58	9.67	3.54	20.8	17.7	75.5
<i>n</i> = 100 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	99.9%-quantile RMSE	99.9%-quantile Bias	99.9%-quantile RMSE	99%-quantile Bias	99.9%-quantile RMSE	99.9%-quantile Bias	99.9%-quantile RMSE
ML	-0.24	4.01	-0.39	5.76	0.355	8.11	2.39	19.2
L-Moments	0.101	4.71	0.103	6.86	0.23	7.78	1.83	18.3
TL(1,1)-Moments	0.256	4.71	0.38	6.97	0.755	10.2	4.19	26.8
TL(0,1)-Moments	0.117	4.32	0.159	6.22	1.206	14.1	5.14	33.8
MD	-0.01	4.48	-0.03	6.55	1.37	12.7	6.59	34.6
<i>n</i> = 200 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	99.9%-quantile RMSE	99.9%-quantile Bias	99.9%-quantile RMSE	99%-quantile Bias	99.9%-quantile RMSE	99.9%-quantile Bias	99.9%-quantile RMSE
ML	-0.192	2.95	-0.31	4.24	-0.07	5.24	0.373	11.7
L-Moments	-0.061	3.24	-0.09	4.72	-0.08	5.16	0.476	11.8
TL(1,1)-Moments	0.029	3.32	0.022	4.86	0.747	7.42	2.95	18.3
TL(0,1)-Moments	0.042	3.03	0.044	4.38	1.49	9.73	4.51	21.8
MD	-0.035	3.29	-0.06	4.81	0.565	8.57	2.3	21.5

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Table 2. Estimation of the 99%- and the 99.9%-quantile for independent, identically Gumbel (100, 10)-distributed random variables with sample size 30, 50, 100 and 200 and simulated extreme events.

<i>n</i> = 30 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile		99.9%-quantile		99%-quantile		99.9%-quantile	
	Bias	RMSE	Bias	RMSE	Bias	RMSE	Bias	RMSE
ML	6.29	9.79	8.90	14.0	27.7	34.8	81.7	123
L-Moments	11.8	14.2	17.2	20.7	26.7	29.3	74.1	84.6
TL(1,1)-Moments	4.67	10.7	6.84	15.7	18.9	34.9	66.4	135
TL(0,1)-Moments	3.04	8.83	4.32	12.7	15.4	31.1	47.8	99.1
MD	2.80	9.75	3.96	14.3	25.1	53.2	103	315

<i>n</i> = 50 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile		99.9%-quantile		99%-quantile		99.9%-quantile	
	Bias	RMSE	Bias	RMSE	Bias	RMSE	Bias	RMSE
ML	3.81	6.89	5.37	9.84	16.2	19.9	42.7	57.0
L-Moments	6.81	8.90	10.1	13.0	15.7	18.6	41.1	50.5
TL(1,1)-Moments	3.06	7.73	4.46	11.3	10.2	22.2	31.7	70.0
TL(0,1)-Moments	2.35	6.85	3.34	9.84	8.60	20.5	25.0	58.4
MD	1.70	7.32	2.39	10.7	12.3	29.9	43.9	117

<i>n</i> = 100 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile		99.9%-quantile		99%-quantile		99.9%-quantile	
	Bias	RMSE	Bias	RMSE	Bias	RMSE	Bias	RMSE
ML	3.87	5.60	5.50	8.01	14.2	16.0	35.0	40.7
L-Moments	6.85	8.01	10.1	11.8	15.2	16.7	38.1	42.9
TL(1,1)-Moments	3.25	6.09	4.78	8.95	12.0	17.8	32.5	50.8
TL(0,1)-Moments	2.30	4.92	3.26	7.10	8.50	15.3	21.7	40.4
MD	2.14	5.33	3.05	7.75	9.54	18.3	26.6	52.5

<i>n</i> = 200 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile		99.9%-quantile		99%-quantile		99.9%-quantile	
	Bias	RMSE	Bias	RMSE	Bias	RMSE	Bias	RMSE
ML	4.04	4.96	5.78	7.09	13.9	14.8	33.0	35.7
L-Moments	6.92	7.60	10.2	11.1	14.9	15.6	36.7	39.1
TL(1,1)-Moments	3.37	4.81	4.95	7.10	11.5	14.5	29.0	38.3
TL(0,1)-Moments	2.23	3.87	3.14	5.55	8.73	12.5	20.8	31.3
MD	2.12	4.01	3.04	5.82	7.63	12.8	18.7	32.9

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Table 3. Estimation of the 99 %- and the 99.9 %-quantile for independent, identically GEV (0.1, 100, 10)-distributed random variables with sample size 30, 50, 100 and 200.

<i>n</i> = 30 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	99.9 %- RMSE	quantile Bias	RMSE	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE
ML	-10.6	13.8	-28.1	29.2	2.68	27.3	21.9	103
L-Moments	-7.08	13.3	-22.7	28.1	0.292	21.3	8.34	65.9
TL(1,1)-Moments	-8.74	13.3	-25.0	29.0	5.63	33.3	37.2	138
TL(0,1)-Moments	-11.0	14.0	-28.6	31.1	7.11	34.5	36.9	133
MD	-11.2	14.9	-28.7	32.1	11.6	58.3	86.5	550
<i>n</i> = 50 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE
ML	-10.7	12.6	-28.1	29.7	0.939	18.2	8.94	56.0
L-Moments	-6.64	11.0	-22.0	25.5	-0.05	17.5	4.75	51.6
TL(1,1)-Moments	-9.37	12.3	-26.0	28.4	3.92	23.3	20.9	83.6
TL(0,1)-Moments	-10.9	12.9	-28.5	30.1	2.97	23.1	16.1	79.2
MD	-11.0	12.1	-28.4	29.3	6.93	34.1	39.8	167
<i>n</i> = 100 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE
ML	-9.98	10.5	-27.1	27.5	0.718	12.1	4.67	33.9
L-Moments	-6.95	8.14	-22.5	23.3	-0.17	11.8	2.13	32.8
TL(1,1)-Moments	-9.19	9.93	-25.7	26.3	2.01	15.6	10.2	47.2
TL(0,1)-Moments	-10.9	11.9	-28.4	29.2	2.17	15.1	9.41	44.2
MD	-11.0	12.1	-28.4	29.3	1.84	17.9	11.1	56.7
<i>n</i> = 200 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE
ML	-9.98	10.5	-27.1	27.5	0.167	8.23	1.77	21.9
L-Moments	-6.95	8.14	-22.5	23.3	0.301	8.36	1.90	22.4
TL(1,1)-Moments	-9.19	9.93	-25.7	26.3	1.06	10.3	4.83	29.9
TL(0,1)-Moments	10.2	11.6	-28.8	29.1	1.19	10.6	4.89	30.2
MD	-10.7	11.3	-28.0	28.5	2.07	12.3	8.33	36.3

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Table 4. Estimation of the 99%- and the 99.9%-quantile for independent, identically GEV (0.1, 100, 10)-distributed random variables with sample size 30, 50, 100 and 200 and simulated extreme events.

$n = 30$ Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	RMSE	99.9%- quantile Bias	RMSE	99%- quantile Bias	RMSE	99.9%- quantile Bias	RMSE
ML	-0.363	8.75	-13.3	18.2	46.5	60.4	172	283
L-Moments	11.0	14.9	4.02	15.1	43.8	47.4	150	168
TL(1,1)-Moments	-3.08	12.0	-16.7	23.8	31.7	56.5	135	284
TL(0,1)-Moments	-7.09	11.5	-22.9	26.3	27.0	51.6	105	221
MD	-6.92	13.1	-22.6	27.8	38.4	95.3	216	917
$n = 50$ Estimator	Gumbel-Fitting				GEV-Fitting			
	99%- quantile Bias	RMSE	99.9%- quantile Bias	RMSE	99%- quantile Bias	RMSE	99.9%- quantile Bias	RMSE
ML	-4.12	8.19	-18.7	21.3	25.1	31.7	79.4	110
L-Moments	3.85	9.03	-6.57	13.6	27.1	30.4	85.6	98.5
TL(1,1)-Moments	-5.33	10.1	-20.0	23.6	17.3	32.6	61.9	123
TL(0,1)-Moments	-8.75	11.3	-25.3	27.3	15.3	33.0	53.2	117
MD	-8.68	11.7	-25.1	27.5	18.7	41.8	75.9	186
$n = 100$ Estimator	Gumbel-Fitting				GEV-Fitting			
	99%- quantile Bias	RMSE	99.9%- quantile Bias	RMSE	99%- quantile Bias	RMSE	99.9%- quantile Bias	RMSE
ML	-3.98	6.28	-18.4	19.7	23.3	26.3	68.8	80.4
L-Moments	3.69	6.95	-6.80	10.9	26.2	28.4	81.3	90.1
TL(1,1)-Moments	-4.79	7.53	-19.2	21.0	18.2	26.8	59.1	92.2
TL(0,1)-Moments	-8.73	9.97	-25.3	26.2	14.7	23.6	44.3	74.0
MD	-8.46	10.2	-24.7	26.0	13.8	27.3	47.0	96.3
$n = 200$ Estimator	Gumbel-Fitting				GEV-Fitting			
	99%- quantile Bias	RMSE	99.9%- quantile Bias	RMSE	99%- quantile Bias	RMSE	99.9%- quantile Bias	RMSE
ML	-3.71	5.10	-18.0	18.7	21.6	23.1	60.9	66.2
L-Moments	3.84	5.63	-6.59	8.92	25.1	26.2	75.6	79.6
TL(1,1)-Moments	-5.08	6.49	-19.6	20.5	18.8	23.2	58.0	74.1
TL(0,1)-Moments	-8.18	8.93	-24.5	25.0	14.5	19.7	41.4	58.2
MD	-8.37	9.29	-24.6	25.3	11.8	19.2	35.3	60.3

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Table 5. Estimation of the 99 %- and the 99.9 %-quantile for independent, identically GEV (0.2, 100, 10)-distributed random variables with sample size 30, 50, 100 and 200.

<i>n</i> = 30 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	99.9 %- RMSE	quantile Bias	RMSE	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE
ML	-23.6	26.4	-71.8	73.8	10.5	68.1	101	1233
L-Moments	73.0	78.0	314	343	0.435	33.7	18.8	145
TL(1,1)-Moments	-21.7	25.2	-68.5	70.9	5.94	45.7	53.5	226
TL(0,1)-Moments	-26.9	28.7	-76.5	77.8	7.56	44.7	51.6	205
MD	-25.7	27.9	-74.7	76.4	23.7	82.8	172	607
<i>n</i> = 50 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE
ML	-23.7	25.3	-72.0	73.1	2.50	28.3	22.0	111
L-Moments	43.5	49.0	173	178	0.009	24.5	9.69	93.5
TL(1,1)-Moments	-21.8	23.9	-68.7	70.0	5.03	32.7	33.9	132
TL(0,1)-Moments	-26.6	27.7	-76.0	76.8	5.69	34.7	34.74	141
MD	-26.2	27.5	-75.3	76.2	11.0	48.2	69.3	248
<i>n</i> = 100 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE
ML	-23.3	24.1	-71.3	71.8	1.98	19.2	11.2	63.8
L-Moments	-17.2	18.9	-62.0	63.1	-0.65	17.9	2.84	60.5
TL(1,1)-Moments	-22.2	23.1	-69.1	69.8	2.74	21.8	16.5	78.5
TL(0,1)-Moments	-26.6	27.2	-76.1	76.5	2.23	22.9	14.5	79.8
MD	-25.6	26.3	-74.3	74.8	5.27	28.8	29.2	115
<i>n</i> = 200 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE	99%- Bias	quantile RMSE	99.9 %- Bias	quantile RMSE
ML	-23.2	23.6	-71.1	71.5	0.874	12.8	5.67	41.9
L-Moments	-17.1	18.1	-61.9	62.6	0.11	13.3	2.98	44.1
TL(1,1)-Moments	-22.3	22.7	-69.3	69.7	1.92	16.1	11.1	57.6
TL(0,1)-Moments	-26.6	26.9	-76.0	76.2	1.69	15.2	8.49	50.8
MD	-25.8	26.2	-74.7	74.9	2.05	18.5	11.4	65.8

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Table 6. Estimation of the 99%- and the 99.9%-quantile for independent, identically GEV (0.2, 100, 10)-distributed random variables with sample size 30, 50, 100 and 200 and simulated extreme events.

<i>n</i> = 30 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	RMSE	99.9%-quantile Bias	RMSE	99%-quantile Bias	RMSE	99.9%-quantile Bias	RMSE
ML	-7.16	13.6	-47.9	50.7	84.6	122	436	1254
L-Moments	11.4	17.6	-19.8	27.9	73.0	78.0	314	343
TL(1,1)-Moments	-14.8	20.1	-58.2	61.6	51.9	95.3	292	646
TL(0,1)-Moments	-21.6	24.3	-68.9	70.7	43.4	79.5	201	419
MD	-22.0	25.1	-69.1	71.4	63.3	146	439	1504
<i>n</i> = 50 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	RMSE	99.9%-quantile Bias	RMSE	99%-quantile Bias	RMSE	99.9%-quantile Bias	RMSE
ML	-13.6	16.3	-57.2	58.6	40.6	53.8	160	239
L-Moments	0.530	11.5	-35.9	39.5	43.5	49.0	173	201
TL(1,1)-Moments	-17.5	20.2	-62.3	64.0	28.5	53.6	131	257
TL(0,1)-Moments	-23.8	25.1	-72.0	72.9	22.6	47.4	95.1	206
MD	-23.4	24.9	-71.1	72.3	28.9	65.1	145	347
<i>n</i> = 100 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	RMSE	99.9%-quantile Bias	RMSE	99%-quantile Bias	RMSE	99.9%-quantile Bias	RMSE
ML	-13.7	15.2	-57.3	58.1	36.1	42.1	131	160
L-Moments	0.290	7.97	-36.2	38.0	42.6	45.6	162	176
TL(1,1)-Moments	-16.9	18.3	-61.3	62.1	32.6	45.6	132.2	197
TL(0,1)-Moments	-22.9	23.6	-70.7	71.2	24.4	37.7	91.3	149
MD	-23.8	24.6	-71.8	72.4	20.8	39.3	84.2	165
<i>n</i> = 200 Estimator	Gumbel-Fitting				GEV-Fitting			
	99%-quantile Bias	RMSE	99.9%-quantile Bias	RMSE	99%-quantile Bias	RMSE	99.9%-quantile Bias	RMSE
ML	-13.6	14.3	-57.2	57.5	34.4	37.5	119	133
L-Moments	-0.489	5.93	-37.3	38.3	41.9	43.4	157	164
TL(1,1)-Moments	-16.2	17.0	-60.3	60.7	31.8	38.1	120	151
TL(0,1)-Moments	-23.0	23.3	-70.8	71.1	23.4	30.3	81.0	109
MD	-23.6	24.1	-71.5	71.8	16.9	28.1	61.0	105

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