

V.3.3-STAT-QME MEAN DAILY DISCHARGES STATISTICAL SUMMARY OPERATION

Identifier: STAT-QME

Application: Calibration System programs only

Description: This Operation computes statistics for mean daily simulated and observed discharges.

The equations used in the statistics calculations are given in an Appendix following the documentation for this Operation.

The following options are available:

1. computation of multi-year or yearly and multi-year statistics
2. computation and display of quarterly accumulated discharges and errors
3. computation and display of cumulative frequency table
4. computation and display of discharge exceedence plot
5. specification of flow intervals to be used in interval table

Allowable Data Time Intervals: 24 hours

Time Series Used: Time series used in this Operation are as follows:

General Type	Dimn	Units	Use	Required	Form of Output T.S.	Data Time Interval	Missing Values Allowed
Mean daily simulated discharge	L3	CMSD	I	yes	n/a	24	yes
Mean daily observed discharge	L3	CMSD	I	yes	n/a	24	yes

Input Summary: The card input for this Operation is as follows:

Card	Format	Columns	Contents
1	5A4	1-20	General heading information
	F10.1	21-30	Drainage area of basin for which statistics are to be computed (KM2)
	2X,2A4	33-40	Internal identifier of simulated discharge time series
	1X,A4	42-45	Data type code of simulated discharge

<u>Card</u>	<u>Format</u>	<u>Columns</u>	<u>Contents</u>
			time series
	3X,I2	49-50	Data time interval of simulated discharge time series
	2X,2A4	53-60	Internal identifier of observed discharge time series
	1X,A4	62-65	Data type code of observed discharge time series
	3X,I2	69-70	Data time interval of observed discharge time series
	1X,I1	72	Indicator to allow optional statistical output; enter '1' if optional output to be specified on Card 2

Card 2 is optional and should only be used if column 72 of Card is '1'.

2	1X,A4	2-5	Option to compute and print yearly statistics; enter 'YEAR' to specify option; leave blank to obtain only multi-year statistics
	1X,A4	7-10	Option to compute and print quarterly accumulated discharges and errors; enter 'QUAR' to specify option
	1X,A4	12-15	Option to compute and print cumulative frequency table; enter 'FREQ' to specify option
	F10.0	16-25	Option to compute and print discharge exceedence plot; enter maximum discharge to be plotted or enter '-1.' to have program compute scale
	6F5.0	26-55	Option to specify the flow intervals in the statistical summary; enter values to be used (CMSD) in increasing order, or leave blank and default values will be computed

Sample Input and Output: Sample input for this Operation and a sample of the output from the parameter print routine are shown in Figure 1. Sample output from the execution routine is shown in Figure 3.

Equations: The following equations are used to compute statistics for the mean daily discharge statistical summary.

Equations used in both yearly and multi-year computations

1. Simulated mean, S.M. (CMSD):

$$S.M. = \frac{\sum_{i=1}^N S_i}{N}$$

S = simulated daily discharge
N = number of events

2. Observed mean, Q.M. (CMSD):

$$Q.M. = \frac{\sum_{i=1}^N Q_i}{N}$$

Q = observed daily discharge

3. Percent bias, P.B. (%):

$$P.B. = \left[\frac{\sum_{i=1}^N (S_i - Q_i)}{\sum_{i=1}^N Q_i} \right] * 100$$

4. Monthly bias, M.B. (MM):

$$M.B. = \left(\frac{\sum_{i=1}^N (S_i - Q_i)}{N} \right) \left(\frac{86.4}{AREA} \right)$$

AREA = watershed area in KM²

86.4 = conversion factor from CMSD/KM² to MM

5. Maximum error, Max.E. (CMSD):

$$Max.E. = \max_{i=1}^N (S_i - Q_i)$$

6. Percent average absolute error, P.A.E. (%):

$$P.A.E. = \left[\frac{\sum_{i=1}^N (|S_i - Q_i|)}{\frac{N}{\bar{Q}}} \right] * 100$$

7. Percent RMS error, %.RMS.E. (%):

$$%.RMS.E. = \left[\frac{\left(\frac{\sum_{i=1}^N (S_i - Q_i)^2}{N} \right)^{0.5}}{\bar{Q}} \right] * 100$$

8. Daily RMS error, D.RMS.E. (CMSD):

$$D.RMS.E. = \left(\frac{\sum_{i=1}^N (S_i - Q_i)^2}{N} \right)^{0.5}$$

9. Daily average absolute error, D.A.E. (CMSD):

$$D.A.E. = \frac{\sum_{i=1}^N |S_i - Q_i|}{N}$$

10. Correlation coefficient for daily flows, R:

$$R = \frac{N * \sum_{i=1}^N S_i Q_i - \sum_{i=1}^N S_i * \sum_{i=1}^N Q_i}{\left[\left(N * \sum_{i=1}^N S_i^2 - \left(\sum_{i=1}^N S_i \right)^2 \right) \left(N * \sum_{i=1}^N Q_i^2 - \left(\sum_{i=1}^N Q_i \right)^2 \right) \right]^{0.5}}$$

11. Line of best fit: $Q = A + B * S$

$$A = \bar{Q} - B * \bar{S}$$

$$B = \frac{N * \left(\sum_{i=1}^N S_i * Q_i \right) - \sum_{i=1}^N S_i * \sum_{i=1}^N Q_i}{N * \sum_{i=1}^N S_i^2 - \left(\sum_{i=1}^N S_i \right)^2}$$

Equations used only in multi-year computations

12. Maximum monthly volume error, Max.M.V.E. (MM)

$$\text{Max.M.V.E.} = \text{MAX} \left. \frac{MS_i - MQ_i}{\text{AREA}} (86.4) \right|_{i=1}^M$$

M = number of months
 MS = monthly simulated volume
 MQ = monthly observed volume

13. Percent average absolute monthly volume error, Ave.M.V.E. (%)

$$\text{Ave.M.V.E.} = \left[\frac{\sum_{i=1}^M |MS_i - MQ_i|}{\sum_{i=1}^M MQ_i} \right] * 100$$

14. Percent monthly volume RMS error, %.M.V.RMS (%):

$$\% . M . V . R M S = \left[\frac{\left(\frac{\sum_{i=1}^M \frac{(M S_i - M Q_i)^2}{M}}{M} \right)^{0.5}}{\frac{\sum_{i=1}^M M Q_i}{M}} \right] * 100$$

15. 25 largest daily error values in CMSD:

A. Percent of the total square deviation, %Tot.Sq.Dev. (%):

$$\% . T o t . S q . D e v . = \left(\frac{(S-Q)_L^2}{\sum_{i=1}^N (S_i - Q_i)^2} \right) * 100$$

(S-Q)L = one of the 25 largest daily errors

B. Percent reduction of daily RMS if error equals zero, %Red.RMS (%):

$$\% . R e d . R M S = \left[\frac{\left(\frac{\sum_{i=1}^N (S_i - Q_i)^2}{N} \right)^{0.5} - \left(\frac{\sum_{i=1}^N (S_i - Q_i)^2 - (S-Q)_L^2}{N} \right)^{0.5}}{\left(\frac{\sum_{i=1}^N (S_i - Q_i)^2}{N} \right)^{0.5}} \right] * 100$$

16. 12 monthly volume errors:

Calculations are analogous to those in 15A and 15B

Equations used to compute optional statistical output

17. Accumulated flow (MM):

A. Error (MM) = ASj - AQj

ASj = accumulated simulated volume for 3-month period j

AQj = accumulated observed volume for 3-month period j

B. Accumulated error, Acum.E (MM):

$$\text{Acum.E.} = \sum_{j=1}^K (AS_j - AQ_j)$$

K = number of 3-month periods

18. Cumulative frequency table percent error for each case, P.E. (%):

$$\text{P.E.} = \left(\frac{|S_i - Q_i|}{Q_i} \right) * 100$$

19. Discharge exceedence plot:

Each S_i and Q_i is compared against the plotting intervals and the number of cases exceeding each interval is accumulated.

The modified correlation coefficient, R_m , for daily flows (McCuen, Richard H. and Willard M. Snyder: 'A Proposed Index for Comparing Hydrographs', Water Resources Research, Vol. 11, No. 6, Dec. 1975) is no longer tabulated but can be computed by:

$R_m = B$ if B/R is less than 1.0

otherwise

$R_m = R^{**2}/B$

Figure 1. Sample card input for Operation STAT-QME

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          - Column -
    5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
BIRD CREEK                2344.          BIRD-API SQME    24  BIRD-CK. QME    24 1
YEAR QUAR FREQ  500.
  
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Figure 2. Sample output from Operation STAT-QME print parameter routine

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STATISTICS OPERATION FOR BIRD CREEK
TIME SERIES USED BY THIS OPERATION.
      CONTENTS              I.D.      TYPE      TIME INTERVAL
SIMULATED DISCHARGE        BIRD-API    SQME      24 HOURS
OBSERVED DISCHARGE        BIRD-CK.    QME      24 HOURS
MULTIYEAR AND YEARLY STATISTICS WILL BE COMPUTED.
OPTIONAL STATISTICAL OUTPUT SELECTED:
  1. QUARTERLY FLOW ACCUMULATION TABLE
  2. CUMULATIVE FREQUENCY TABLE
  3. DISCHARGE EXCEEDENCE PLOT, WITH MAXIMUM DISCHARGE OF      500. CMS
  
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Figure 3a. Yearly statistical output for Operation STAT-QME

STATISTICAL SUMMARY											
BIRD CREEK		AREA (SQ KM) = 2344.00				WATER YEAR 1958					
MONTH	SIMULATED		OBSERVED		MONTHLY		MAXIMUM		PERCENT		
	MEAN (CMSD)	ERROR (CMSD)	MEAN (CMSD)	ERROR (CMSD)	BIAS (MM)	(SIM-OBS) (CMSD)	ERROR (SIM-OBS) (CMSD)	AVERAGE ABSOLUTE ERROR	PERCENT RMS ERROR	PERCENT RMS ERROR	
OCTOBER	4.231	0.386	995.97	4.393	35.332	995.97	2282.06				
NOVEMBER	10.705	0.995	975.60	10.737	57.138	975.60	1724.71				
DECEMBER	5.774	0.473	1120.18	6.057	60.655	1134.14	2956.36				
JANUARY	6.813	1.925	253.99	5.586	58.017	275.67	698.11				
FEBRUARY	3.878	0.613	532.89	3.370	38.395	544.13	1563.24				
MARCH	38.404	44.281	-13.27	-6.716	-73.897	39.63	56.70				
APRIL	11.400	16.415	-30.55	-5.545	-59.634	46.81	96.67				
MAY	4.431	5.019	-11.72	-0.672	-14.263	52.69	90.48				
JUNE	4.679	0.396	1082.51	4.736	27.307	1082.99	1989.81				
JULY	12.050	5.971	101.82	6.947	37.147	101.82	182.98				
AUGUST	1.602	2.572	-37.74	-1.109	-22.628	90.78	223.40				
SEPTEMBER	10.564	1.650	540.31	9.857	51.155	540.31	993.27				
YEAR AVG	9.593	6.795	41.17	37.640	-73.897	94.66	200.64				
DAILY RMS ERROR (CMSD)	13.634	6.433	0.7381	-0.5451	0.7652						
DAILY AVERAGE ABS ERROR (CMSD)											
LINE OF BEST FIT											
OBS = A + B * SIM											
DAILY FLOWS											
NUMBER OF CASES											
FLOW INTERVAL											
0.0 -	0.87	197	3.659	0.405	803.97	0.1199	60.655	810.10	2209.47		
0.87 -	2.71	67	7.898	1.523	418.53	0.2350	57.138	431.76	868.05		
2.71 -	8.68	45	8.501	4.557	86.55	0.1454	58.017	116.39	244.88		
8.68 -	27.13	32	19.412	16.090	20.64	0.1224	41.060	70.86	96.79		
27.13 -	86.81	19	43.424	51.259	-15.29	-0.2888	-59.634	48.87	58.77		
86.81 -	271.29	5	84.531	120.912	-30.09	-1.3410	-73.897	30.09	36.57		
271.29 AND ABOVE		NO CASES									

Figure 3b. Multi-year statistical output from Operation STAT-QME

MULTIYEAR STATISTICAL SUMMARY

BIRD CREEK AREA (SQ KM) = 2344.00 WATER YEARS 1957 TO 1959

MONTHLY	SIMULATED		OBSERVED		MONTHLY BIAS (SIM-OBS) (MM)	MONTHLY MAXIMUM ERROR (CMSD)	PERCENT AVERAGE ABSOLUTE ERROR	PERCENT DAILY RMS ERROR	MAX MONTHLY VOLUME ERROR (MM)	PERCENT AVG MONTHLY VOL ERROR	PERCENT MONTHLY RMS ERROR
	MEAN (CMSD)	STANDARD DEVIATION (CMSD)	MEAN (CMSD)	STANDARD DEVIATION (CMSD)							
OCTOBER	5.651	0.150	N/A	N/A	6.285	118.473	N/A	N/A	14.160	N/A	N/A
NOVEMBER	11.164	0.494	2159.66	11.799	140.138	2161.16	4931.04	19.914	2159.68	2442.92	2442.92
DECEMBER	5.607	0.205	2634.31	6.173	68.311	2647.84	6722.28	11.836	2634.34	3279.47	3279.47
JANUARY	3.375	0.708	376.42	3.047	58.017	400.55	1144.31	5.586	376.42	444.22	444.22
FEBRUARY	6.955	0.449	1448.08	6.714	68.679	1453.19	3060.23	9.441	1448.10	1546.48	1546.48
MARCH	21.424	16.017	33.76	6.179	-73.897	82.51	131.47	13.005	58.22	60.20	60.20
APRIL	38.176	26.094	46.30	13.360	141.697	63.64	123.91	38.835	59.11	79.66	79.66
MAY	61.280	64.481	-4.97	-3.659	-182.134	34.14	62.66	-10.841	5.45	8.52	8.52
JUNE	50.771	57.666	-11.96	-7.624	-252.770	31.80	78.32	-31.962	21.46	29.52	29.52
JULY	14.937	19.519	-23.47	-5.236	-156.896	50.21	142.52	-22.024	44.24	59.80	59.80
AUGUST	1.280	2.366	-45.88	-1.240	-22.628	91.27	162.57	-3.491	67.58	80.47	80.47
SEPTEMBER	18.628	4.595	305.39	15.518	246.673	332.95	884.95	21.508	305.39	319.45	319.45
YEAR AVG	19.937	16.123	23.66	51.316	-252.770	66.27	169.53	38.835	49.16	68.93	68.93

DAILY RMS ERROR (CMSD)	DAILY AVERAGE ABS ERROR (CMSD)	MONTHLY VOLUME RMS ERROR (MM)	CORRELATION COEFFICIENT DAILY FLOWS	LINE OF BEST FIT	
				OBS = A + B*SIM	B
27.334	10.685	12.469	0.8916	-4.8339	1.0511

Figure 3b. Multi-year statistical output from Operation STAT-QME
(continued)

FLOW INTERVAL	NUMBER OF CASES	SIMULATED MEAN (CMSD)	OBSERVED MEAN (CMSD)	PERCENT BIAS	OBSERVED BIAS (SIM-OBS) (MM)	MAXIMUM ERROR (CMSD)	PERCENT AVG ABS ERROR	PERCENT RMS ERROR
0.0 -	590	4.877	0.232	1998.24	0.1712	140.138	2006.17	5961.84
0.87 -	168	8.042	1.653	386.65	0.2355	68.679	420.17	835.64
2.71 -	146	8.982	4.546	97.57	0.1635	58.017	144.05	277.44
8.68 -	74	29.768	16.910	76.04	0.4739	160.242	102.43	183.02
27.13 -	67	67.836	50.515	34.29	0.6384	246.673	67.05	105.24
86.81 -	35	134.702	157.896	-14.69	-0.8550	-156.896	29.41	39.60
271.29 AND ABOVE	15	321.944	427.615	-24.71	-3.8951	-252.770	25.72	30.34

MONTH	DAY	YEAR	OBSERVED	SIMULATED	ERROR (SIM-OBS)	PERCENT ERROR	TOTAL SQ DEVIATION	PERCENT REDUCTION OF DAILY RMS IF ERROR EQUAL ZERO
JUNE	13	1957	731.597	478.827	-252.770	-34.55	7.81	3.98
SEPTEMBER	26	1959	43.669	290.342	246.673	564.87	7.44	3.79
JUNE	14	1957	507.581	304.719	-202.862	-39.97	5.03	2.55
MAY	21	1957	365.799	183.665	-182.134	-49.79	4.05	2.05
MAY	26	1957	615.335	443.183	-172.152	-27.98	3.62	1.83
JUNE	25	1957	487.731	318.954	-168.778	-34.60	3.48	1.76
SEPTEMBER	27	1959	12.505	172.748	160.242	1281.41	3.14	1.58
JULY	23	1959	254.358	97.461	-156.896	-61.68	3.01	1.52
JULY	16	1959	260.596	105.288	-155.308	-59.60	2.95	1.49
APRIL	1	1957	29.207	170.905	141.697	485.15	2.45	1.23
NOVEMBER	6	1956	0.0	140.138	140.138	-0.00	2.40	1.21
SEPTEMBER	25	1959	28.924	165.262	136.338	471.37	2.27	1.14
APRIL	2	1957	39.132	160.951	121.819	311.30	1.81	0.91
SEPTEMBER	16	1957	20.473	141.556	121.082	591.41	1.79	0.90
NOVEMBER	5	1956	0.0	120.288	120.288	-0.00	1.77	0.89
JULY	20	1959	158.796	39.274	-119.523	-75.27	1.75	0.88
OCTOBER	15	1956	0.0	118.473	118.473	-0.00	1.72	0.86
MAY	27	1959	226.001	110.732	-115.269	-51.00	1.62	0.82
JUNE	3	1957	331.771	221.804	-109.966	-33.15	1.48	0.74
JUNE	24	1957	482.060	373.058	-109.002	-22.61	1.45	0.73
MAY	25	1957	391.319	283.253	-108.067	-27.62	1.43	0.72
OCTOBER	16	1956	0.0	105.883	105.883	-0.00	1.37	0.69
SEPTEMBER	15	1957	28.924	132.255	103.331	357.25	1.31	0.65
APRIL	4	1957	48.490	147.681	99.191	204.56	1.20	0.60
MAY	22	1959	147.454	50.276	-97.178	-65.90	1.15	0.58

25 LARGEST DAILY ERROR VALUES IN CMSD

Figure 3b. Multi-year statistical output from Operation STAT-QME
(continued)

12 LARGEST MONTHLY VOLUME ERRORS IN MM									
MONTH	YEAR	OBSERVED	SIMULATED	ERROR (SIM-OBS)	PERCENT ERROR	PERCENT TOTAL SQ DEVIATION	PERCENT REDUCTION OF MONTHLY RMS IF ERROR EQUAL ZERO		
APRIL	1957	64.443	103.278	38.835	60.26	26.96	14.54		
JUNE	1957	184.050	152.089	-31.962	-17.37	18.26	9.59		
JULY	1959	50.823	28.799	-22.024	-43.33	8.67	4.43		
SEPTEMBER	1959	8.481	29.988	21.508	253.61	8.27	4.22		
NOVEMBER	1956	0.0	19.914	19.914	N/A	7.09	3.61		
SEPTEMBER	1957	4.939	20.127	15.188	307.53	4.12	2.08		
OCTOBER	1956	0.0	14.160	14.160	N/A	3.58	1.81		
MARCH	1959	4.071	17.076	13.005	319.47	3.02	1.52		
MARCH	1957	0.236	12.483	12.247	5189.18	2.68	1.35		
DECEMBER	1956	0.002	11.838	11.836	N/A	2.50	1.26		
MAY	1957	168.975	158.134	-10.841	-6.42	2.10	1.06		
NOVEMBER	1957	1.101	11.837	10.737	975.60	2.06	1.04		

ACCUMULATED FLOW IN MM									
PERIOD	YEAR	OBSERVED	SIMULATED	ACC ERROR	ERROR THIS PERIOD				
OCTOBER	1956	0.00	45.91	45.91	45.91				
JANUARY	1957	0.28	70.46	70.17	24.26				
APRIL	1957	417.75	483.96	66.21	-3.97				
JULY	1957	435.83	513.11	77.27	11.07				
OCTOBER	1957	437.91	536.37	98.46	21.19				
JANUARY	1958	491.34	592.04	100.70	2.24				
APRIL	1958	515.67	614.89	99.22	-1.48				
JULY	1958	527.25	642.17	114.91	15.69				
OCTOBER	1958	528.03	648.62	120.59	5.68				
JANUARY	1959	533.04	674.95	141.91	21.32				
APRIL	1959	590.17	743.75	153.59	11.68				
JULY	1959	650.76	804.71	153.95	0.36				

Figure 3b. Multi-year statistical output from Operation STAT-QME
(continued)

CUMULATIVE FREQUENCY TABLE

TOTAL NUMBER OF CASES = 1095

NUMBER OF CASES	PERCENT ERROR	PERCENT OF TOTAL CASES
19 LE	2.0	1.74
31 LE	4.0	2.83
50 LE	6.0	4.57
63 LE	8.0	5.75
76 LE	10.0	6.94
87 LE	12.0	7.95
99 LE	14.0	9.04
110 LE	16.0	10.05
121 LE	18.0	11.05
134 LE	20.0	12.24
143 LE	22.0	13.06
160 LE	24.0	14.61
169 LE	26.0	15.43
181 LE	28.0	16.53
192 LE	30.0	17.53
206 LE	32.0	18.81
222 LE	34.0	20.27
230 LE	36.0	21.00
239 LE	38.0	21.83
249 LE	40.0	22.74
259 LE	42.0	23.65
266 LE	44.0	24.29
278 LE	46.0	25.39
284 LE	48.0	25.94
290 LE	50.0	26.48
314 LE	55.0	28.68
330 LE	60.0	30.14
349 LE	65.0	31.87
366 LE	70.0	33.42
379 LE	75.0	34.61
394 LE	80.0	35.98
409 LE	85.0	37.35
418 LE	90.0	38.17
438 LE	95.0	40.00
467 LE	100.0	42.65
494 LE	110.0	45.11
507 LE	120.0	46.30
525 LE	130.0	47.95
539 LE	140.0	49.22
554 LE	150.0	50.59
560 LE	160.0	51.14

Figure 3b. Multi-year statistical output from Operation STAT-QME
(continued)

